COMPASS

perspectives & tools to benefit southern forest resources

summer 2005

Crowning Glory

Is longleaf restoration possible?

Southern Research Station

USDA Forest Service

INSIDE... THE SCIENCE

DEPARTMENTS

COMPASS

Science You Can Use!

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perspectives & tools to benefit southern forest resources

Compass is a quarterly publication of the USDA Forest Service Southern Research Station (SRS). As part of the Nation's largest forestry research organization—USDA Forest Service Research and Development—SRS serves 13 Southern States and beyond. The Station's 130 scientists work at more than 20 units located across the region at Federal laboratories, universities, and experimental forests.

Future issues can be obtained by returning the postcard included in this issue.

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The mission of the Southern Research Station is to create the science and technology needed to sustain and enhance southern forest ecosystems and the benefits they provide.

Cover photo exhibits longleaf pine male flowers. *(Erich G. Vallery, USDA Forest Service, www.forestryimages.org)*

Background: Hurricanes Katrina and Rita caused extensive damage to southern forests—an opportunity for longleaf restoration? *(Peter L. Lorio, Jr., USDA Forest Service, www.forestryimages.org)*

Inset: Longleaf pine seedling braves the wrath of Hurricane Katrina *(Jim Caldwell, USDA Forest Service)*

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CROWNING GLORY

by Kelli Whitlock Burton

William Boyer crawled out of the white Chevy Blazer and stretched his 6-foot-plus long frame, working out the kinks from the 3-hour drive from Auburn to the small town of Flomaton, AL. Donning a baseball cap, he quickly drenched his shoes and trouser cuffs with insect repellent. A veteran of the southern Alabama woods, Boyer knew the bugs would be biting among the pine trees on this humid June afternoon.

Longleaf pines once towered over 90 million acres in the Southeast. Today, barely 3 million acres of longleaf forest remain. Is restoration possible?

At his feet lay a Natural Heritage Site marker blown over by Hurricane Ivan, a category 2 storm that, on September 16, 2004, made landfall about 100 miles southwest from where Boyer now stood. His gaze lifted to the woods in front of him, his eyes settling on the familiar rough-edged bark of the long-needled giants that swayed gently beneath a gray sky. When the hurricane roared onto land 9 months before, the east side of the forest at Flomaton bore the brunt of its 120-mile-per-hour sustained winds, which some have estimated knocked down over half the forest. With trees dating back 200 and 300 years, the 60-acre Flomaton Natural Area is one of the last remaining stands of old-growth longleaf pine, the dominant species in an ecosystem that once covered more than 90 million acres from Texas to Virginia.

Boyer stepped lightly around the grasses and flowering plants that covered the ground, his eyes trained on the forest floor. Alongside him, colleagues **Dale Brockway** and **Kris Connor** kept a keen watch below as well, searching, like Boyer, for something in particular. They didn't have to look long. As Boyer brushed back the vegetation, he discovered a pile of long, bright green needles surrounding a small tan bud. A longleaf pine seedling. He spotted several others in the same area, and began to smile. "This is good to see," Boyer said. "Very good."

With time, good weather, and room to grow, these short, grassy-looking plants will one day tower high above the forest floor. "Imagine what this place looked like hundreds of years ago, when Flomaton, and much of the Southeast, was covered with longleaf pine," suggested Boyer's colleague Brockway, gazing at the trees that are left, their perfectly linear trunks stretching as high as 100 feet, topped with branches that end in elegant needles extending up to 15 inches in length. As the small group of researchers stood silently, the wind blowing through the trees' crowns filled the forest with earthy music that was peaceful and somber. "Longleaf as far as the eye could see," Brockway said. "Wouldn't that have been a sight?"

Boyer looked down, as if to observe a moment of silence for the passing of a friend. Once the keystone species—that upon which all the others depend—in the largest single-tree-dominated ecosystem in the United States, longleaf pine now occupies just under 3 million acres, less than 5 percent of its original territory. Boyer and Brockway, researchers with the **Southern Research Station (SRS) unit in Auburn, AL** and Connor, the unit's project leader, are among a growing number of longleaf enthusiasts working to keep those numbers from dwindling even further by collaborating in efforts to protect the trees that remain and to restore longleaf to some of its native range.

It's an arduous process. The timber industry long ago turned its sights to other pine species that mature more quickly, such as loblolly and slash. Development has left much of longleaf's native soils buried under concrete; the absence of prescribed burning, critical to the longleaf's success, has allowed hardwoods and other competitors to take over the forests. Funding for longleaf research is limited and many of the Nation's leading longleaf scientists, like Boyer, have retired or are retiring. The species' reputation as hard to grow hasn't helped matters.

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Young longleaf pine *(Zoë Hoyle, USDA Forest Service)*

Longleaf Pine Facts
(Pinus palustris)

- Keystone species in an ecosystem that once dominated the Coastal Plain of the Southeastern United States
- Just over 200 years ago covered up to 90 million acres from southwest Virginia through east Texas
- Reduced to 3 million acres by harvest for timber, early hog grazing, production of naval stores such as turpentine, and conversion of land to agriculture, pine plantations, and development
- Resilience to low-intensity fire allows longleaf pine to dominate as competitors are burned out of the midstory
- Longest needles of any southern pine contain a high level of combustible resins
- Sporadic seed production: every few years, all the longleaf pines in a region will produce seeds
- Seedlings initially do not grow in height but remain on the ground in a grass stage, which can last from 2 to over 10 years
- After grass stage, seedlings go into early height growth, when they can grow as much as 4 to 6 feet a year
- Longleaf pine ecosystem supports over 300 threatened and endangered species

Immature longleaf pine cones in mid-September *(William D. Boyer, USDA Forest Service, www.forestryimages.org)*

Crowning Glory

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Boyer and his colleagues say much of that is just plain myth. They're convinced that if more people knew the story of longleaf and understood how to grow it, the tree would experience a revival that would save it from dwindling further, as well as the hundreds of plants and animals that depend on the longleaf ecosystem for survival.

The Story of a Forest Brought Low

Before the last ice age, longleaf pine trees are believed to have started out in Mexico and Texas. But about 8,000 years ago, the ancient pines began to migrate north and east, ultimately taking up residence across the Atlantic and Gulf Coastal Plains. Longleaf thrived for centuries, due in part, researchers suspect, to fire started by lightning or set by Native Americans. Intolerant of competition for space, sun, and nutrients, longleaf forests are healthiest when fire removes midstory woody trees and other species of pine, giving longleaf pine trees unfettered access to the sun and room to grow.

For many years, European settlers adopted the Native American practice of routinely clearing the forest floor with fire. Longleaf was prized for its quality timber, however, and any desire to preserve these majestic forests gave way to the economic windfall brought by their harvest. By the early 1900s, most of the country's longleaf pines could be found not in forests, but in the "heart pine" floors of mansions and cottages, in the masts of ships, in docks and wharfs, and in the frames of buildings in many of the Nation's large cities. Even the Brooklyn Bridge boasts a longleaf tie.

As forests fell to saws and axes, industry and private landowners tried to replace the trees with a new generation of longleaf. But many of the seeds would not generate, and those that did yielded seedlings that grew at a painfully slow pace. Longleaf's dependence on fire and intolerance to competition had not yet been fully studied, so many just thought the tree incapable of quick and healthy growth. Loblolly and slash pine, on the other hand, sprouted and grew quickly, ready for harvest after just 10 years. Lands traditionally occupied by longleaf were replanted with these more economically desirable pines, and longleaf took another step toward extinction. Today, the National Biological Survey lists the longleaf ecosystem, whose pines once covered two-thirds of the Southeast, as the second most-endangered ecosystem in the United States. (Wetlands rank first.)

When SRS was first established as the Southern Forest Experiment Station in the 1920s, one of its first research priorities was to study longleaf pine ecosystems. Boyer, a native of Ohio educated in Syracuse, joined the USDA Forest Service in 1955. Until then, he had never laid eyes on a longleaf pine. Before long, he found himself a champion of the endangered tree, enamored of its fortitude and resilience, and of the iridescent shimmer of its graceful needles. Boyer began his studies at the **Escambia Experimental Forest**, a 3,000-acre tract near Brewton, AL, owned by T.R. Miller Mill Company. The company, interested in the higher prices longleaf timber commanded, leased the property to the Forest Service in 1947 as a laboratory with the hope that Forest Service scientists could find ways to ensure longleaf's restoration.

Over the next nearly 20 years, Boyer and his colleagues learned much about ways to improve longleaf's chances of survival. Despite those advances, the challenges of growing longleaf persisted and industry all but abandoned the storied pine in favor of loblolly and slash. Then, in the mid-1970s, research related to longleaf pine was deemphasized and the need for the 3,000-acre Escambia Experimental Forest was questioned. This was bad news for Boyer. If the Agency ended its 99-year lease with T.R. Miller, hundreds of longleaf pine trees studied so carefully for nearly three decades would surely be cut down and sold.

Boyer and fellow SRS scientist **Robert Farrar** quickly drafted a position paper to support the continuance of the experimental forest. Instead of emphasizing the merits of longleaf research, the pair's strategy was to argue that the long-term studies of prescribed burning in the experimental forest were too valuable to abandon. Although controlled burning had become less popular with land managers in the South, new research—some of it from the Escambia Experimental Forest—suggested that regular, supervised burns were necessary for good forest management. Their arguments were successful and the lease with T.R. Miller continued. And so did Boyer's research on longleaf.

"We just continued to do the longleaf research on the side," Boyer says, "under the radar."

About 400 miles west, **James Barnett** was slipping under that same radar. Barnett, now project leader of the **SRS unit in Pineville, LA**, had also spent years working on longleaf pine, focusing most of his research on improving the quality of longleaf seeds harvested and stored for planting. Barnett and his colleagues in Pineville diversified their pine studies at the **Palustris Experimental Forest**, part of the Kisatchie National Forest about 20 miles southwest of Alexandria, LA. Although they conducted a wide range of studies on loblolly and slash, they also continued their work with longleaf restoration.

"Almost everything you do with longleaf is different than other pine species, more interesting and more challenging," Barnett says. That challenge was one reason for Barnett's persistence. Another was a sincere belief that longleaf could survive and thrive. "Everything about longleaf is difficult," Barnett says.

Including, as it turns out, walking away from it.

Restoring From the Ground Up

Before the Forest Service turned its attention to other research areas in the mid-1970s, Barnett was working on seed production, an area that for decades had proven a stalwart obstacle to successful longleaf planting. Landowners and industry workers had tried to use the same collection and storage techniques for longleaf used successfully for other pine species. But as Barnett noted, everything about longleaf is different, right down to their seeds. After 7 years of study, Barnett developed a method for collecting, storing, and planting longleaf pine seeds that greatly increased seed viability. First, he discovered that unlike other pine seeds, which can be collected in early fall, longleaf seeds do best when gathered after the whole seed crop has matured—usually late October or early November.

One problem with seed viability had been finding the lowest temperature they could tolerate during storage. Too warm and the seeds would rot. Too cold and they would crack. Barnett discovered that by lowering the seeds' moisture content to below 10 percent and freezing them at temperatures ranging from 0 to 25 degrees Fahrenheit, longleaf seeds could be stored for as long as 20 years and remain capable of producing healthy seedlings.

By the time Barnett solved the seed problem in 1975, many professional foresters had turned their attention away from longleaf. Interest likely would have continued to wane were it not for the red-cockaded woodpecker, which makes its home in longleaf pine forests. In the 1980s, when scientists realized that the number of red-cockaded woodpeckers had dwindled to the point of near extinction, the Federal Government began to require the restoration of the bird's habitat on public lands where it had previously nested, and to provide incentives for restoration on private lands. This renewed interest in longleaf ecosystems was a welcome turn of events for Boyer, Barnett, and their colleagues.

Suddenly, a new market for Barnett's work with seed production emerged. Soon after, Barnett turned his attention to another issue with longleaf restoration. Many landowners who planted longleaf from seed were finding that the seedlings did not have good survival rates. With other plants, survival is often improved if the seeds are planted first in a container, carefully tended for one or two growing seasons, and then transplanted into the ground. At the time, it was widely believed that longleaf could not be grown in containers. People also once thought that longleaf seed couldn't be stored, Barnett thought. Perhaps they were underestimating longleaf once again.

Barnett spent years perfecting his container-growing method, using receptacles of varying sizes made with a number of different materials. He found that plastic containers about 1½ inches in diameter and 6 inches deep seem to be the most efficient, both in cost and production. Longleaf planted from seed have a 50- to 70-percent chance of survival; Barnett's container-grown longleaf seedlings have a 90- to 95-percent survival rate. Although the plastic containers he uses are the cheapest of all the types he studied, it's still twice as expensive as growing longleaf from seed. But spending the extra money up front, Barnett says, pays off with healthier trees down the road.

A Long-Term Relationship with Fire

The suppression of naturally caused fire over most of the last century seriously unbalanced forest ecosystems across the United States. Without fire, understory and midstory growth in all types of forests went unchecked. This was especially damaging to longleaf pine. Habitats once dominated by longleaf and characterized by open spaces filled with low-growing wiregrass or

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Taking the Bite Out of the Blight

by Zoë Hoyle

The fungus *Scirrhia acicola*, better known as brown spot needle blight, attacks 28 species of pines. But it inflicts the most damage on the longleaf pine, killing seedlings in the earliest stage of their development. Researchers at the **Southern Institute of Forest Genetics in Saucier, MS**, combine the latest in genetic mapping tools with classic genetic breeding to give longleaf seedlings a better shot at surviving the blight.

Longleaf pines start their lives in a unique grass stage, the seedlings almost stemless, resembling clumps of long shining grass. The grass stage can last anywhere from 2 to over 10 years, depending on growing conditions. Longleaf pine is most susceptible to brown spot needle blight during this stage. The fungus attacks the needles, leaving only a bare stem. Seedlings infected with the blight either die or grow very slowly. Heavily infected longleaf pine seedlings may stay in the grass stage for a decade or more. Seedlings with resistance to the blight grow much faster and taller, with height gains persisting for decades.

Following the grass stage, the seedling enters a period of rapid growth, called early height growth, sometimes known as the rocket stage. Seedlings can resist the blight much more easily during this stage. That's why, says Saucier unit project leader **Dana Nelson**, the group has focused on prompting longleaf seedlings to enter the early height growth stage sooner.

"How long seedlings stay in the grass stage determines the health of the future longleaf stand," Nelson says. "Getting seedlings to enter the early height growth stage in the first or second year keeps the disease from building up." This can be done by reducing the competition for light by thinning the forest, or by selecting plants more genetically inclined to enter early height growth sooner.

Southern Research Station researchers have used the **Harrison Experimental Forest** near Saucier to conduct studies of mature tree growth rates since the early 1960s. Nelson and his colleagues use the forest to carry out their breeding studies, crossing longleaf with slash pine to determine the genes responsible

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Blight *(continued from page 3)*

for the timing of the grass stage. They're also working to develop a variety of longleaf pine that moves into early height growth during its first year.

Tom Kubisiak, research geneticist with the Saucier unit, contributes expertise in genetic mapping. He uses statistical analysis to locate sites on the pine genome that affect traits like early height growth and blight resistance. Kubisiak and Nelson use DNA markers developed from their mapping studies to select the seedlings used in classical breeding research.

Another Saucier researcher goes FISHing to learn more about the genes that affect longleaf pine resistance to blight. **Nurul Faridi**, research cytogeneticist located at College Station, TX, uses fluorescent in situ hybridization, or FISH—a molecular biology tool that allows scientists to mark specific pieces of genetic code with fluorescent tags—to locate genes in the pine genome. Combining DNA marker and fluorescent techniques not only helps unit researchers to learn more about the genes affecting important traits, but also allows them to distinguish one pine species from another.

Saucier researchers recently analyzed the third generation of trees from test plots in Mississippi and Louisiana, where seedlings were selected for their resistance to the blight. At 9 years, researchers found that both resistance and early growth had increased. They predict that the fourth generation of seedlings will have almost twice the resistance found in the first.

"These studies show that we can systematically increase resistance to blight in longleaf pine by selective breeding," Nelson says. "We can use the new technologies to design the seed orchards that will in turn produce the resistant seedlings needed to successfully grow longleaf pine."

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Crowning Glory

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bluestem grasses had become thick with shrubs and woody tree species, a tangled disorder that looked more like a teenager's messy bedroom than a classic longleaf savanna.

Boyer had examined the use of fire in longleaf management through several long-term studies at the Escambia Experimental Forest. Even though he officially retired from the Forest Service in 1998, Boyer has continued to follow the studies he began in the 1960s. Longleaf, he found, is surprisingly resistant to low-intensity fire; longleaf seeds actually require fire to germinate. While it's true that blazes that burn too hot can scorch some trees and kill some grass-stage seedlings, others survive, and once they stand higher than 4 to 6 feet, they're generally safe from fire.

"Burning doesn't make longleaf grow better. It allows the longleaf pine habitat to exist," says **James Haywood**, a research forester at the Pineville unit who has studied fire in different pine ecosystems for two decades. "Yes, you do kill some regeneration with fire, but you don't kill all of it. You're sacrificing tree growth in some for the overall betterment of the habitat."

Other fire studies have looked at how fire can be combined with herbicide and the mechanical removal of woody species. Boyer's studies suggest that a combination of the three methods works best to get an unkempt forest under control. Then, regular prescribed burns can be used to maintain the classic longleaf habitat. That begs the question, though, of just how often to burn. **Kenneth Outcalt**, a research plant ecologist with the **SRS unit in Athens, GA**, says that prescribed burns every 2 years offer the best results.

"There's a big dividing line between 2 and 3 years and we've found that waiting for 3 years gives the woody species too much time to recover," he says. "If you really want to change the composition, you need fire at least every 2 years, which allows you to reduce the amount of woody species and increase the herbaceous grasses and plants. It's more in tune with what the natural system looked like."

Forming an Alliance

Through the years, SRS scientists have directed their attention toward raising public awareness about the benefits of longleaf and offering information to disprove myths about longleaf growth. Key to these efforts has been the **Longleaf Alliance**, an advocacy organization that SRS helped to found in 1994. Made up of 600 to 800 people in 20 States, the alliance is a collaboration among environmentalists, timber industry representatives, government forest ecologists, and university scientists who are committed to longleaf restoration. The alliance hosts workshops, information booths, and other awareness campaigns to provide information about growing longleaf.

"There's a lot of passion behind this," says Dean Gjerstad, codirector of the alliance. "We just really believe in longleaf."

Some 170,000 acres of longleaf were planted in the 1990s, Gjerstad says, due in large part to the alliance's education efforts. One of their challenges has been to overcome the fear that because longleaf takes longer to mature than other pine species, planting longleaf just isn't economically feasible. Loblolly and slash pine can be harvested after just 10 to 12 years. Longleaf isn't ready for timber production for at least 20 years, usually longer. But there's more to longleaf than timber, Gjerstad is quick to point out. There's a growing market for pine straw, a prime component in mulch products, and longleaf pine—with its glorious long needles—offers a bumper crop of pine straw in just 10 years after planting. The payoff can be as much as $50 an acre per year. And once longleaf is ready to be sold, it usually commands a much higher price than loblolly or slash because of its quality, height, and ramrod straightness. Longleaf is often used for utility poles, which garners a good profit for the timber industry.

The Forest Service is also looking for new ways to incorporate longleaf restoration into rural development. One idea has been to partner with tribal nations to produce and sell container-grown longleaf seedlings, a project under development with the Poarch Band of Creek Indians Reservation near Atmore, AL. The program would be similar to a successful effort out West called the Intertribal Nursery Council, which involves 68 tribes and 7 tribal colleges in growing and selling a variety of native trees and plants.

But development is only part of the campaign. There also is a need to counter misinformation about longleaf growth and sustainability. Although the Longleaf Alliance, SRS and other agencies, and individual scientists have done much to educate landowners and industry about these ancient trees, there remains a skepticism that Boyer says is unfounded.

"It's clear from our studies that longleaf pine grows faster and is a more prolific seeder than once thought," Boyer says. "Longleaf has been here for thousands of years, so clearly, regeneration does work."

The end goal of all this work is not to return longleaf to its post ice age dominance in the Southeast, Outcalt says. But great strides can be made in restoring the ecosystem, and these efforts have already shown some success. Since 1996, the Longleaf Alliance estimates that 600 million longleaf seedlings have been planted on about 1 million acres.

"Longleaf pine is never going to return to the number of acres that it once occupied. That's not really necessary or realistic," he says. "We're trying to restore health, which is not the same thing. We can't go back in time. The idea is to have the general structure and composition of what historical stands look like."

With time and persistence, SRS researchers believe they can get more and more people to buy into this idea. Longleaf is an easy story to sell, they say, once you remove the myth from the picture. And as Boyer is quick to note, restoring longleaf is about more than just saving a tree that has stood its ground on American soil for centuries. It's about preserving an entire ecosystem and the hundreds of plants and animals that depend on that habitat for survival.

"These trees have been here for thousands of years," Boyer notes, paying tribute to the perseverance of a species he has spent a career studying and almost an entire lifetime championing. "To lose them now . . . well, we just can't let that happen."

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Longleaf pine seedling survives prescribed burning *(Zoë Hoyle, USDA Forest Service)*


Jim Barnett *(Kelli Whitlock Burton)*

a CONVERSATION with Two Leaders in Longleaf Pine Research

by Claire Payne

Jim Barnett leads the **Ecology and Management of Even-Aged Southern Pine Forests Research unit** in Pineville, LA. Charlie McMahon led the **Vegetation Management Research and Longleaf Pine Research for Southern Forest Ecosystems unit** in Auburn, AL. Barnett will soon retire with almost 50 years in the Forest Service. McMahon retired in 2004, after having worked for the Forest Service for 31 years and 10 with the Department of Defense.

When and where did you first see a longleaf pine forest?

Barnett: In 1955, when I first saw a longleaf forest, it was a sea of black stumps—more than hundreds per acre. That grassland near Alexandria, LA, went on for 20 to 30 to 50 miles, southwest to Texas. There were a few mature trees, neat trees with long cones, mainly along the roadway. It was an open range with grazing cattle and hogs, primarily cattle. In the 1960s, I did see a mature longleaf savanna on the Kisatchie National Forest in central Louisiana. Prescribed fire had been used repeatedly, and there was a grass understory. A longleaf ecosystem thrives in southwestern Louisiana on the Calcasieu Ranger District near Fort Polk, LA. Lots of red-cockaded woodpeckers live there. In the western part of the South—Texas, Louisiana, and parts of Mississippi—the timber industry moved across the land practicing railroad logging in the 1910s and 1920s. Steam engines ran on railroad trams, or tracks, pulling a skidder/loader. On each side of the skidder, cables ran out 1,000 to 1,500 feet, pulling in logs. If the trees weren't cut, the cables knocked them down. The skidder, which had a big hole in it, was positioned over the railroad tracks. The railroad cars actually went through the skidder! In Louisiana, several million acres were harvested in this way. Reforestation didn't begin until the 1950s. There was a saying that you could stand on a longleaf stump in Alexandria and see the Mississippi River. The second longleaf harvest began in the 1970s when the stumps were dug up, extracted by bulldozers, or blown out of the ground with dynamite. When I came to the Palustris Experimental Forest, it had been stumped. Someone offered to buy the stumps, but we said we'd keep what we had.

McMahon: When I joined the Southern Station in 1987 as project leader for the silviculture unit in Auburn, I also became responsible for the administration of the Escambia Experimental Forest in southern Alabama. The Escambia is a longleaf pine experimental forest that was established in 1947 in cooperation with the T.R. Miller Mill Company. The Escambia contains all age classes of the tree and many long-term studies and management demonstrations. Up to this point, my experiences and perceptions of longleaf pine were through the eyes of a northern city dweller turned into a "fire and smoke" scientist in 1973 at the former USDA Forest Service Fire Laboratory in Macon, GA. When I transferred to Auburn, things changed . . . daily chats and discussions with Bill Boyer (known as "Dr. Longleaf" to many people), and a few visits to the Escambia gave me a new and broader perspective about the tree, the forest, and the related concerns about the decline of the greater longleaf ecosystem.

Ironically, this was at a time when the Forest Service "new perspectives" and "ecosystem management" philosophies and programs were emerging, bringing national attention to many forest ecosystems that were degraded, fragmented, or otherwise in decline. This provided us (and many other longleaf advocates) with new opportunities to highlight and promote the multiple benefits of longleaf pine to both public and private landowners and managers. Soon longleaf pine research, management, and restoration initiatives began to emerge across the South from several Federal Agencies, and other State and private groups.

What surprised you most in your research?

Barnett: How different longleaf regeneration is from other pine species. It amazed me that when we harvested this species—which grows from Texas to Virginia—we couldn't replace them. The technology wasn't there, so longleaf was replaced with other species.

In 1946, the Forest Service established a research laboratory in Alexandria, LA. Everything about longleaf is more difficult than loblolly and slash pine: seed production, processing, nursery practices, planting, and storage. Longleaf is intolerant to shade and susceptible to being overwhelmed by other species. It was a big hurdle to establish stands. Planting containerized seedlings was more expensive, but even with the failure of some seedlings, you could still have a success in establishing a stand. The survival rate was 75 to 85 percent. The survival rate for bare-root seedlings was only 50 to 60 percent.

McMahon: My connection to longleaf research was as a program leader and manager not as a primary researcher. Some say I was a cheerleader and I readily admit to that. The thing that surprised me the most in my role was the level of passion displayed by all of the primary researchers who were active in this broad arena. I was also surprised to see how well the "boots" and "sandals" researchers got along—"boots" representing the tree-oriented, production-oriented researchers and "sandals" representing the biologists and ecologists who were ecosystem oriented, or focused on the understory function and related plant and wildlife communities.

Are there any components missing from our restoration efforts?

Barnett: Research needs to determine how a longleaf stand compares in timber productivity with loblolly. Longleaf grows straight and tall. Compared to loblolly, longleaf trees can be sold at a premium for poles and pilings. We have needed a growth-and-yield model for at least 25 to 35 years. Longleaf produces solid wood products as well or better than slash and loblolly pine. Once the seedlings get past the grass stage and into high growth, longleaf grows as fast as loblolly or slash. Jeff Goelz, biometrician at the Pineville unit, is working on a prediction model. We're getting close to having a dataset to develop the growth-and-yield model for longleaf.

McMahon: The longleaf recovery (or restoraton, if you wish) effort is a continuum or a broad band of efforts ranging from classic restoration efforts on some large public sites (managed by, for example, the Forest Service, the Department of Defense, and the Department of the Interior), to providing "plantation management" or "stewardship management" guidelines for small, nonindustrial private landowners. Let me quickly add that no longleaf advocate believes we can or should attempt to recover or restore longleaf to the 60 to 90 million acres it once occupied. A more reasonable and achievable goal is to restore health to existing acres and to double the acres occupied from the current 3 million acres to approximately 6 million acres.

While many forest landowners appreciate and understand the high value wood products derived from long-rotation longleaf management, we still lack a good way to assess and capitalize the noncommodity and community values of longleaf pine forests. We don't have sufficient quantitative information about the environmental and ecological benefits of well-managed longleaf pine forests. Water, air, wildlife, and aesthetic values need to be translated into a currency that people understand and relate to on a personal level. Current national policy efforts to assign "carbon credits" for selected forest management strategies may greatly benefit future longleaf recovery on private lands.

One of the biggest gaps of understanding about longleaf pine in the private sector is the lack of awareness that it can outperform other commercial southern pines on poor to marginal sites, as well as hold its own on good sites. The slow early growth of longleaf pine in the grass stage gives the visual impression of poor performance. However, Bill Boyer's research has shown that it will catch up in later years and provide landowners a reasonable return on their investment. Fortunately the old problems of seedling survival have been largely overcome with the use of containerized seedlings, proper control of plant competition, and careful adherence to planting guidelines.

Public land managers in the Southern United States work from a different perspective and a broader agenda for longleaf pine. They manage large tracts on national forests in eight States and several large military bases. Public land managers focus on ecosystem restoration, uneven-aged management, and natural regeneration. Planting longleaf seedlings is only a small part of the story. The expansion of growing season prescribed fire has been used for about 10 years to restore ecosystem health and function. We need to better understand the role of fire in sustaining longleaf ecosystems. On public lands, there is also more attention given to restoring the health of the native plant communities in the understory, and managing the midstory to bring back sustainable levels of critical wildlife species. Although the red-cockaded woodpecker is endangered, now the focus is on restoring healthy communities rather than just a single species.

How can we be more successful?

Barnett: We have a long way to go to get the forest industry interested. It's difficult to get timber companies interested in longleaf because it takes longer to get them started than loblolly and slash.

McMahon: I think we are being successful in both the public and private sectors. On a quantitative level in the private sector, you can look at the last 10 years and see expanded seedling production and acres planted, and the dramatic positive response to State

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Charlie McMahon *(Patricia McMahon)*

CONVERSATION

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and Federal cost-sharing programs for longleaf management. On Federal lands, expanded fire management programs and well-documented plans for longleaf restoration are now underway. This will be a slow but steady process that will take more than 30 years to provide good visual evidence of success. Perhaps more importantly, there has been a major shift in attitudes about longleaf within the forest management community. Not too long ago, longleaf was viewed as a risky investment and much too hard to do. That has been replaced by a "can do, will do" attitude that bodes well for the future of this important southern pine species. At the Federal level, I believe a formal interagency (Forest Service, Department of Defense, and Department of the Interior) initiative would accelerate, connect, and expand landscape levels of longleaf research over the long term.

What is the biggest success story of longleaf restoration?

Barnett: Raising seedlings in containers. Because the plants retain their bare-root systems, they grow twice as fast once they're in the ground. This gives us a much better chance at longleaf regeneration. Natural regeneration of longleaf pine is iffy for several reasons:

1. Competition on the ground. Longleaf doesn't compete well for light or space because its growth is initially slower. Competition can be controlled with fire.

2. Production of seeds. Longleaf doesn't have a good seed crop every year; sometimes there isn't a good seed crop for a decade. (Boyer has been working on a study on seed production on the Kisatchie National Forest for 20 years.)

3. Lack of seed sources. Longleaf needs a stand or a forest for seed-fall. This presents a problem because there are insufficient stands, since longleaf acreage has decreased from 90 million acres to 3 to 4 million acres. Seedlings grown in containers come from national forest and State orchards.

McMahon: I prefer the word recovery or the words "restoration and management." From a broad perspective, I would say the biggest success story over the last 10 years (especially as it relates to success in the private sector) is the success of the Longleaf Alliance, led by codirectors Dean Gjerstad and Rhett Johnson of the Auburn University School of Forestry and Wildlife Sciences. The Alliance has been a catalyst for research and development, a clearinghouse for longleaf information and technology, and a sustaining force for the individual alliance members and institutional partners. The Alliance has sponsored dozens of local technology transfer workshops, produced instructional videos, and coordinated five extremely successful regional conferences over the past 10 years, all of which have contributed greatly to the recovery effort. Specific success stories related to artificial regeneration (containerized seedlings and planting technology), natural regeneration (shelterwood systems), and the benefits of cultural treatments (weed control and prescribed burning technology) are also big themes embedded in the broader story.

If you could look ahead 50 years, what would you see with regard to longleaf forests?

Barnett: I hope we can continue to restore longleaf so we can have large enough acres of ecosystem to maintain it forever. We have 3 to 4 million acres of longleaf now, and we want to double or triple that amount.

McMahon: Stated quite simply:

1. A clear and sustainable reversal of the precipitous decline in the longleaf pine forest type—or ecosystem, if you wear sandals

2. Restoration of health to existing sites

3. More cooperation among public agencies involved in longleaf restoration

4. An expansion of incentives for stewardship management of longleaf pine in the private sector

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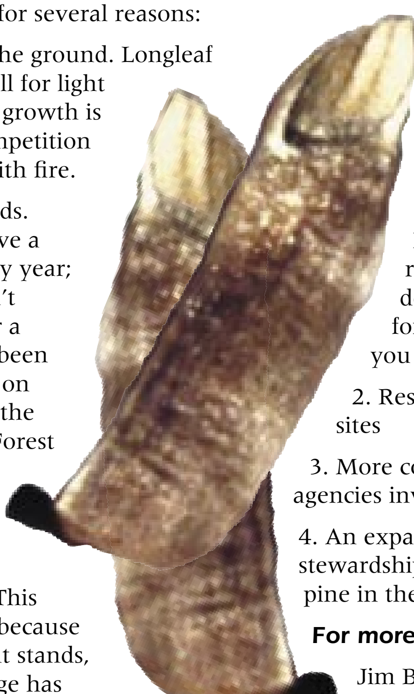

Longleaf pine seed *(David J. Moorhead, The University of Georgia, www.forestryimages.org)*

There's More to Restoration Than Planting Trees

by Zoë Hoyle

Discussions about longleaf pine restoration tend to focus on replanting trees and using prescribed fire, but ecosystem restoration also involves bringing back the ground cover that makes longleaf pine forests some of the richest plant communities on Earth.

"The ground cover of the longleaf pine forest is truly extraordinary," says **Joan Walker**, research plant ecologist with the **Southern Research Station Endangered, Threatened, and Sensitive Wildlife and Plants unit** in Clemson, SC. "One way ecologists describe the diversity of plant communities is by species richness, which refers to the number of species present in an area. Because this number depends on the size of the area where species are counted, ecologists specify the area. This practice allows us to compare various kinds of forests with regards to plant diversity."

"Some longleaf pine communities have over 40 vascular plant species in a square meter, or over 200 species in 100 square meters," she continues. "That's a lot of different species in a small area! In fact, at these scales, the ground layers in longleaf pine woodlands are as species-rich as any area in North America."

Walker should know. She's spent decades identifying the plants that make up the ground layer of longleaf pine forests from North Carolina to Georgia and Florida, carrying the art of field botany to a new generation of students, and working with forest managers to bring back key ground cover plants to areas now being restored to longleaf pine.

No Two Sites the Same

Longleaf pine forests now occupy less than 5 percent of an original range estimated at around 90 million acres. Sites with both old-growth longleaf pine trees (defined as over a century old) and undisturbed understory are very rare—usually small fragments of land that were always too wet, too dry, or too inconvenient to farm or convert to pine plantations.

Second-growth stands (70 to 100 years old) with intact ground layers are more common. The largest blocks of this relatively healthy longleaf forest are found in national forests and on military installations, some managed with regular cycles of prescribed fire. On both private industry lands and military bases across the South, forest managers are expanding longleaf stands by planting seedlings in areas previously planted in loblolly or slash pine—areas where the herbaceous species of the original longleaf forest may have completely disappeared.

"To restore the ecosystem and the function of fire within it, you must restore the ground layer as well as the trees," Walker says. "This can be complicated. Unless you have an intact site nearby to use as a reference, you may not know which plants should be there."

Understory plant communities vary a great deal across longleaf pine's natural range, which stretches from coastal flats with wet depressions, to the Coastal Plains where the land starts to roll, to hills and mountains. Geography plays into species variation, but the most important factors are the frequency of fire and soil characteristics, especially soil moisture.

"Frequently burned sites tend to have more species than those where fire has been eliminated, and wet and intermediate sites support more species than very dry sites," says Walker.

Rich and Resilient

In the fire-managed longleaf forests of the Coastal Plain, it's easy to see how the dominant ground vegetation can vary with the burn cycle. Walk into Brosnan Forest near St. George, SC, in late June and you will see a section burned a year ago dominated by small blueberry bushes and delicate legumes. Another site less than a mile away, burned just 3 weeks before, is already covered with bracken fern, with patches of yellow pitcher plant glowing from the charcoal-tinged forest floor.

Fire brings out the best in these ecosystems. "Most of the plants are sun-loving perennials that resprout after fire, which typically stimulates flowering and seed production," says Walker. "You can walk into a longleaf pine forest at almost any time in the growing season and find something flowering."

The most common plant families in the longleaf pine ground layer are composites, legumes, and grasses. Many of those flowering after fire are composites, plants such as asters whose blooms are actually made up of clusters of small individual flowers. Composites in the longleaf understory also include sunflowers, liatris, bonesets, goldenrod, ironweed, and black-eyed Susan.

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Plant ecologist Joan Walker helps Brian Mudder, Clemson University student, identify understory plants at Brosnan Forest near St. George, SC. Owned by the Norfolk-Southern Corporation, Brosnan Forest consists of over 15,000 acres, most of which is in actively managed longleaf pine forest.

(Zoë Hoyle, USDA Forest Service)

What Lies Beneath?

by Zoë Hoyle

A Southern Research Station (SRS) biologist is looking at dormant seed banks as possible resources for restoring ground layer plants to areas where longleaf pine is being replanted.

The longleaf pine ecosystems that once stretched from Virginia to Texas harbor a rich diversity of ground layer plants. Though roughly 95 percent of the remaining longleaf forests are on dry sites, it is the very wet sites that produce the greatest diversity of understory plants—including some of the highest concentrations of threatened and endangered plant species in the Southeast.

Land managers from the private, industrial, and Federal sectors are replanting longleaf pine on land within its former range, mostly on sites that have been converted to agriculture or loblolly pine plantations—sites that have almost always lost the natural ground cover of the longleaf ecosystem. As we have seen, restoring the ground layer to areas where longleaf pine has been removed, often decades or more before, can be difficult.

In a recent study of wet sites in the Coastal Plain of North Carolina, biologist **Susan Cohen** with the **SRS Biological Foundations Research unit** in Research Triangle Park, NC, compared seed banks from highly disturbed sites with those from relatively intact longleaf stands to verify the presence of seed banks and evaluate them for plant diversity.

The study was conducted in North Carolina's Croatan National Forest. Four disturbed, former longleaf pine sites that had been converted to loblolly pine plantations in the mid-1970s were selected for the research. For comparison, Cohen chose four sites where longleaf pine naturally regenerated in the early 1900s. Included on these second-growth comparison sites were remnant trees up to 200 years old. The two sets of sites were all within several miles of each other and shared a similar history until the 1970s.

Cohen first surveyed the standing vegetation on all the sites. Next, she collected soil from each site, and created optimum greenhouse conditions for

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There's More to Restoration

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Legumes, members of the bean family bearing pealike flowers and pods, fix nitrogen from the atmosphere, replacing what is lost from fire. Legumes can be herbs, vines, or shrubs: species commonly found on longleaf sites include beggarweeds, lespedezas, goat's rue, milkpeas, and dollar leaf.

Because grasses produce fine fuel for frequent surface fires, they are key understory plants across the range of longleaf pine, and are often the first choice for restoration. Coastal Plain grasses include wiregrass, panic grass, and bluestem, with wiregrass the most prominent in the East. From western Alabama to Texas, bluestem grasses replace the wiregrasses in longleaf pine habitats.

Other common families include the sedges and lilies; more unusual plants include orchids and carnivorous species such as pitcher plants and Venus' flytrap. Though the plants that make up the grassy ground layers are exceptionally hardy, they don't survive long without longleaf pine, whose fallen needles feed the low-intensity fires that keep the system alive.

"The longleaf pine tree is not only the most dominant tree species in the ecology, but also a keystone species upon which the others depend," says Walker. "In areas where longleaf pine has disappeared, so have the grassy ground layers. To begin restoring the ecosystem, you need to work at both tree and ground levels."

Ecosystem Restoration as a Continuum

In simple terms, an ecosystem consists of elements—species of plants, in this case—and the processes that connect them. An example of a process is the dispersal of seeds. Fire catalyzes processes like decomposition and stimulates responses such as flowering and seed production.

"Restoring an ecosystem can involve manipulating elements, processes, or both," says Walker. "But what will you restore it to? People often look at longleaf pine restoration as re-creating conditions that existed before the forests were heavily logged, but we only have a vague idea of what those forests really looked like."

"Another way to look at restoration is to see it as converting an unnatural, disturbed condition to its natural condition," she continues. "Both of these approaches—the 'historical' and the 'natural'—imply that there is a single desirable restoration goal."

"I'd like to suggest a different and more inclusive way to think about restoration," Walker continues. "When you look at an area once dominated by longleaf pine, you see places such as parking lots and golf courses that are obviously disturbed, definitely not natural. The area may also include national forests that people consider very natural. Between these two extremes lies a continuum between disturbed and natural. If you use the idea of a continuum, restoration can be seen as a process of moving a site along that continuum towards the more natural."

Where Do You Start?

Ecological restoration—moving an area towards the more natural—can involve adding elements or processes, or both. For longleaf pine areas, this can include restoring native grasses, removing nonnative invasive plants, opening up the forest canopy, or reintroducing fire.

"Because there is so much variation in conditions and land use history across the longleaf pine range, we can't write a manual that will tell landowners exactly how to restore these systems," says Walker. "But we can help them decide where to start in relation to what is already there."

In eastern sand hill areas where managers are replacing loblolly and slash pine with longleaf, replanting wiregrass is a good way to start restoring the ground layer. Wiregrass seeds benefit from the same bare mineral soil that favors longleaf pine seedlings. Wiregrass also provides good fuel for the low-intensity fire needed to clear the soil to mineral and reduce competition from shrubs and small hardwoods.

"In places where fire has been excluded for a long time, just restoring the fire regime is not enough to restore the herb layer," says Walker. "Wiregrass must be replanted before fire can be used effectively as a restoration tool. If restoring biodiversity is a manager's objective, we may also need to add some of those other common and even rare herbs."

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Revitalizing Wiregrass at FORT GORDON

by Zoë Hoyle

We're at Fort Gordon, in the sandhills of Georgia, on a hot, dusty day in late June, standing in what looks at first like just another open field. In the background are stands of loblolly pine; in the foreground, rows of young longleaf pines. Some are in the grass stage, some a foot or so high, others several feet tall with the characteristic candlestick limbs. They were hand planted as seedlings in an area where offsite slash pine was cut to create the sun-drenched gaps longleaf needs to grow. The area has been burned within the last year: the sandy soil is streaked with gray ash, nearby tree trunks scorched.

U.S. Army wildlife technician Aaron Linebarger has just revved up a seed collector—basically a weedeater with a basket contraption on the front—to show us one way wiregrass seeds are collected. Looking closer at the ground, I see clumps of wiregrass, tufts of rough emerald green sprouting out of the sandy soil, in between delicate legumes and passionflower vines. Like the needles of longleaf pine, wiregrass has that certain iridescence. Considered a key ground layer plant in most of the longleaf ecosystems of the South, wiregrass disappears from areas where the soil has been heavily cultivated or where fire has been excluded for long periods of time.

I am here with Southern Research Station (SRS) researchers **Joan Walker** and **Andrea Silletti**, U.S. Army forester Allen Braswell, Nature Conservancy ecologist Angela Collada, and wildlife technician Scott Partridge, looking at a collaborative project to restore the understory typical of the longleaf pine ecosystem to upland sandhill areas on Fort Gordon. On this particular site, some of the trees and wiregrass were planted at the same time. Both are doing well.

Fort Gordon, located near Augusta, GA, sits on 56,000 acres located mostly in the Atlantic Coastal Plain. The installation includes upland sandhills dominated by longleaf pine as well as plantations of loblolly and slash pine. Wiregrass and other characteristic herbaceous species are found throughout the fort lands, but there are relatively few high-quality natural longleaf areas. Fort Gordon managers are working to change that situation through ground cover restoration, reforestation, and prescribed burning.

"We have 46,000 acres in managed forest," says Braswell. "We try to burn at least 15,000 acres every year, with 6,500 acres on a 1-year rotation. Across the base, we've been planting longleaf pine seedlings to reestablish stands of the tree that once dominated this landscape."

A Unique Partnership for Restoration

In 1995, The Nature Conservancy started working with Fort Gordon land managers on an ecosystem-based management plan, a collaboration led by the fort's wildlife biologist Ken Boyd. Together they came up with a plan that identified the ecosystems and species at Fort Gordon, threats to the ecological health of the area, and strategies to address those threats. One of these strategies was to restore ground layer plant communities in current and former longleaf pine areas. In 1997, The Nature Conservancy established an office at Fort Gordon, with Laurie Gawin as project ecologist.

In 1999, Fort Gordon staff received U.S. Department of Defense funding to conduct some habitat restoration. Gawin suggested that they use the plan developed earlier as a guide, and direct the funding towards restoring the understory in longleaf pine stands on the installation. Aware of her work in this area, Boyd and Gawin contacted Walker to help with the restoration.

Walker, Boyd, and Gawin started the project by planting wiregrass in an area recently replanted in longleaf pine which had long ago lost its populations of wiregrass and many of the ground cover plants typical of the longleaf ecosystem. "We started with wiregrass because it forms a matrix for the other ground layer plants in the longleaf pine ecosystem," says Walker. "The other, compelling reason was to bring back the function of fire to the ecosystem."

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What Lies Beneath?

(continued from page 10)

seed germination from each soil sample. The seedlings from each sample were then collected and identified to species.

"Over the course of the study, 1,064 plants germinated from 43 different species," says Cohen. "We had species germinate that we did not find in the vegetation surveys of either the disturbed or undisturbed sites."

Soil from the disturbed sites germinated more individuals from more species, but this was expected. The dominant plant species in natural ecosystems like those on the Croatan sites, which are managed with frequent low-intensity fire, do not accumulate as large a seed bank as those on disturbed sites, where there has been a general shift from herbaceous ground layer plants to woody shrubs.

"While many of the species that germinated from the plantation sites were weedy species typical of disturbed areas not managed by fire, we did find numerous others that are typical of stable longleaf communities," says Cohen. "This study confirmed both the presence and quality of seed banks in wet sites that have been disturbed over three decades. This persistent seed bank may prove an important tool for ground layer restoration."

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Cooperators: Felipe Sanchez, team leader, SRS Biological Foundations Research Unit; Richard Braham, North Carolina State University

Susan Cohen working in the greenhouse. *(USDA Forest Service)*


Wiregrass ecosystem *(Joan Walker, USDA Forest Service)*

WIREGRASS SUPPORTS FIRE

Wiregrass *(Aristida beyrichiana)* is named for its long narrow leaves, which roll in at the margins to give a wirelike appearance. Wiregrass depends on summer burning to stimulate flowering and seed production, and plays an important part in moving fire through the longleaf forest. When longleaf pine needles fall, they are held up by overlapping bunches of wiregrass, allowing air to circulate at the forest floor level. Fire then spreads easily through clumps of highly flammable wiregrass and longleaf pine needles.

FORT GORDON

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Wiregrass provides fuel for the low-intensity fire that longleaf pine depends on to reduce competition from shrubby undergrowth. Wiregrass, too, benefits from burning, which stimulates flowering. Burning off surface debris also exposes bare mineral soil, the sandy charcoal-streaked dirt that wiregrass germinates best in. One of the challenges of restoration is getting back to this soil condition on land that has not been burned for a long time.

"It's been a challenge," says Walker. "The thinning operations and burning Fort Gordon land managers are doing for longleaf pine reduce competition from other plants and expose the mineral soil, but we still have the dry conditions resulting from the seasonal rainfall patterns combined with the low water-holding capacity of the deep sand soils to contend with."

In March 2002, Walker and Fort Gordon agronomist Gary Pringle used a hay blower to spread wiregrass seed onto 2 acres of a restoration site that had been cleared and planted with longleaf pine seedlings. The initial goal was to establish one wiregrass plant per square meter. In 1 year, wiregrass plants on this site were producing seed. Measurements taken in 2005 showed that the density of plants continues to increase, probably from seeds grown on site.

"It's pretty hard to get the seed established on the uneven surfaces of the restoration sites," says Walker. "You can blow out a lot of seeds and not get much germination. We've also used seedling plugs grown in nurseries. These have a high survival rate and are good for establishing a population right away, but they are expensive. We still need to find more cost-effective methods to get wiregrass seeds and to put them in the ground."

Wiregrass seed is fairly hard to come by. There are no consistent commercial sources: most land managers collect seed from nearby longleaf pine forests or from plants they have established from nursery plugs. Seed germination and viability in wiregrass are both unpredictable, for reasons that are not well understood.

But at Fort Gordon, wiregrass is growing from seeds collected nearby and sown onsite. "The good news is that you can restore wiregrass to sites where it has completely disappeared," says Walker. "And, though it's not easy, it's not as difficult as people thought."

Coming Soon: A New Resource for Landowners

The work at Fort Gordon continues to add valuable information about the seeding rates needed to restore wiregrass, the costs of different seeding and planting approaches, and how timber management practices can be used to support ground layer restoration on upland sandhill sites.

Meanwhile, Walker and collaborator Lin Roth are designing a manual for landowners interested in restoring the ground layer of longleaf forests. Along with information on seed harvest and planting, the manual includes guidance for planning restoration projects and detailed case studies for reference. Funded by Fort Gordon, the manual will be made available online in winter 2005.

Roth, an extension forest ecologist with Clemson University, coordinates the work of the manual. "Lin has a keen interest in restoring the longleaf ecosystem and a true commitment to communicating practical information to landowners," says Walker. "After I asked her to take on the project, she visited restoration sites and interviewed people involved in restoration in Florida, Georgia, and the Carolinas. Then she translated and organized that knowledge for the manual. We are looking forward to distributing this information to the many land managers who have been asking for it."

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Cooperators: U.S. Department of Defense, Fort Gordon; The Nature Conservancy, Georgia Chapter; Clemson University

Measuring Restoration at the Ground Level

by Zoë Hoyle

How do scientists and land managers tell if their restoration efforts are working?

Researchers usually mark off plots in the area they have seeded or planted and take random samples within the plots to calculate the percent coverage of the desired plant. When the species they are looking for is rare or not evenly distributed over a plot, taking random samples may miss whole patches of the plant they are looking for, and not give an accurate estimate of restoration. The alternative, counting every plant in the plot, is time consuming and impractical.

At Fort Gordon, GA, **Andrea Silletti,** ecologist with the **Southern Research Station unit at Clemson, SC**, is using a sampling method developed for other challenging situations to evaluate wiregrass restoration in areas where seedlings have come up in patches within large bare areas.

"We were concerned that if we used traditional sampling methods, we would spend a lot of time sampling areas that had no wiregrass, and that our estimates would not reflect the actual density of the plant," says Silletti.

Silletti started with a method called adaptive cluster sampling. Units within a plot are randomly chosen for sampling. If a unit contains wiregrass, the units on each side of the sample are also sampled. If any of these also contain wiregrass, the process is repeated.

"We sample out to the edge of the cluster," says Silletti. "This allows us to sample more of the area that we expect to have plants. We use calculations derived from other research to take into account the bias of the sampling and to come up with an estimate of the number of plants, rather than percent cover."

"The purpose of adaptive sampling is to get the most precise estimate of abundance or density for a given effort," she continues. "These methods are particularly useful for sites where the target plant is rare, clustered, unpredictable, elusive, or hard to detect."

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a RESIN for Being

by Frank Stephenson

Technician insatalling brood box for red-cockaded woodpecker in Texas *(Richard Conner, USDA Forest Service)*

A 4-foot long rat snake, its shiny gray coils tightened around a perch 35 feet up a shortleaf pine, lifts its head towards a hole further up the trunk. The snake flicks its tongue to "smell" its prey—red-cockaded woodpecker nestlings, still sound asleep, oblivious to the danger lurking just below them.

But the tiny birds aren't all the snake detects. A smear of fresh pine resin lies between the snake and its prey. Arching its body out from the tree to avoid the resin, the snake falls to the ground and slithers off.

Scenes like this are played out every day in the eternal struggle of predator vs. prey. But in this case, the prey—the endangered red-cockaded woodpecker—is able to use an innate, almost chemical knowledge of its primary habitat to thwart its foe. The birds bet their survival on the ability to find pine trees that can produce an adequate supply of resin to block rat snakes from raiding their nests and destroying their communities.

It wasn't until the late 1970s, after the bird rose to official endangered status, that scientists began to fully appreciate this and other curious facts about the red-cockaded woodpecker. Taken for granted for centuries—its population once numbering into the untold millions across the southern Coastal Plains—in the 1960s, the bird was found to be clinging to existence in highly scattered groups living mainly in the remnants of old-growth longleaf pine forests from North Carolina to Texas. Today, less than 13,000 red-cockaded woodpeckers are thought to exist. The species' survival remains a preeminent management priority for the USDA Forest Service, and a perpetual source of intrigue for people like Richard Conner.

Richard N. "Dick" Conner is a wildlife biologist with the Forest Service, **Southern Research Station unit at Nacogdoches, TX**. In 2001, he and colleagues **Craig Rudolph**, a research ecologist also attached to the Nacogdoches unit, and Jeffrey R. Walters, a professor at Virginia Tech who, like his two coauthors, ranks among the top red-cockaded woodpecker scientists in the country, coauthored what is considered the most comprehensive overview of research on the red-cockaded woodpecker ever published. The 363-page volume, The Red-cockaded Woodpecker: Surviving in a Fire-Maintained Ecosystem, published in 2001 by the University of Texas Press, is an invaluable primer for anyone seeking an indepth understanding of the bird's biology and natural history.

If nothing else, the book testifies to the intense and irrepressible interest among scientists in a species that may be too finicky for its own good. Nature's uncompromising edict—adapt or die—could have been inspired by this small, tenacious bird with exacting tastes in what it eats, where it lives, and how it builds its nests. The main reason the bird is within an eye-blink of extinction has nothing to do with the diet of rat snakes. It's because the bird won't, or can't, easily adapt to life in anything but pine trees, and particular pine trees at that.

Unlike most open-nesting birds that use straw, twigs, moss, and other materials to build nests, red-cockaded woodpeckers only lay their eggs in holes, or cavities, that they laboriously carve into the trunks of certain pine trees. If the birds can't find suitable pines for such hole-making, they don't reproduce. Older trees—those at least 90 years old—offer the best cavity-building opportunities for a variety of reasons, most of which have to do with the peculiarity of the bird's favorite tree—the longleaf pine.

For more than 5,000 years, the red-cockaded woodpecker's primary habitat was a 2,000-mile stretch of longleaf forest that essentially shaded the entire South. By 1930, logging had erased all but a few thousand acres of these highly prized and long-lived (up to 400 years) pines, and the impact on the birds has been devastating. Alternative pine forests—predominately shortleaf and loblolly pines, the latter grown commercially in vast acreages—harbor some healthy red-cockaded populations, but still don't come close to offering the best habitat, longleaf pine forest, where the bird thrives.

Conner and his colleagues think they know why. In recent years, remarkable gains have been made by the Forest

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Animals Adapted to a Disappearing Habitat

Species abundance and richness in the longleaf pine ecosystem is not limited to plants. Across a range—and diversity of habitats—that stretches from Virginia to Texas, longleaf pine forests host a wide range of animal species, many uniquely adapted to the fire forest.

The ecosystem includes 90 to 100 species of birds; around 40 of these are found in the forest year round, with the rest migrating into longleaf range to breed or overwinter.

Around 36 mammals can be found in the longleaf pine ecosystem: over a third of these are rodents.

The highest density of amphibians and reptiles in North America has been mapped over longleaf forests; almost 60 percent of the 290 reptile and amphibian species native to the Southeast can be found within the tree's present range. Snakes and lizards make up the largest portion, with around 35 species.

Herpetofauna—snakes, lizards, and amphibians—are of the greatest conservation concern: 18 percent of the amphibians and 47 percent of the snakes in the States that include longleaf forests are threatened to some extent.

Like the red-cockaded woodpecker featured here, the future existence of many of these species is endangered by the continued fragmentation of this important habitat.

Information used with permission from Georgia Wildlife Press.

Male, 24-day old red-cockaded woodpecker being fed by a helper at the nest cavity entrance *(©Derrick Hamrick, Images of the Wild)*

RESIN for Being

(continued from page 13)

Service and private foresters in using artificial means in longleaf, shortleaf, and loblolly pines to keep woodpeckers happy even as the birds' preferred longleaf ecosystem continues to vanish. Biologists have learned how to design, build, and install artificial nesting cavities. Conner says they've also learned something perhaps just as important: how *not* to build them.

Researchers can vouch for the popularity of the artificial cavities. Sometimes woodpeckers arrive before foresters can climb down from their ladders. But herein lies a potentially serious problem. The successful installation of artificial nest-building cavities has everything to do with resin, says Conner.

"When you first install these things, there aren't any resin wells (holes tapping into the tree's flowing resin), so in a sense, you may be creating a trap for the birds, making them susceptible to snakes. We've developed techniques to deal with this."

Biologists at the Nacogdoches unit have learned to use a draw-knife to shave a yard of bark near the base of the pine beneath a newly installed cavity. This creates a smooth surface that denies snakes a "foothold"—so to speak—and buys time for the birds to dig their own resin wells, which they do in short order, Conner says.

Over the years, Conner has become an expert on the curious relationship between the red-cockaded woodpecker and pine resin. In the mid-1970s, when Jerry Jackson (then at Mississippi State University) noted the importance of resin wells to the safety of woodpecker young, Conner and his colleagues decided to explore the link between resin and woodpeckers further. Their findings shed new light on this odd relationship.

Conner is convinced that at some point in its ancestry, the red-cockaded woodpecker—the only member of the woodpecker family that regularly excavates its nesting cavities in living pines—learned how to use the sticky resin to its advantage.

The bird digs out its nesting cavity in the heartwood of older pine trees, an effort that can take from 1 to 6 years. The age of the tree is important because old pines offer heartwood that is big enough in diameter to house the birds comfortably. But in the course of routinely keeping their holes excavated, the birds also learned that flowing resin around the perimeter of their holes made a dandy deterrent for tree-climbing predatory snakes.

And when it came to resin, the birds also learned that no other pine species could match longleaf's prodigious capacity for producing the stuff and for far longer periods of time. Eventually, a tree's ability to produce resin became a key factor in its being chosen by the birds for a place to set up house.

"Over time, I can see selection favoring those individual birds who could peck more and make more resin wells, and keep a daily, fresh flow of resin down the nest tree," Conner says.

Conner's own research has turned up evidence that this is indeed the case. Among trees that produce different amounts of resin, the breeding male birds, who bear the chief responsibility for finding suitable nesting sites, invariably pick the trees that produce the most resin. A breeding male will even try to take over another member's tree to get a higher resin level.

"The male starts out by selecting the tree with the most resin production capability for his roost cavity," says Conner. "Then the breeding male's roost cavity becomes the nest cavity when the breeding female lays her eggs in it. That way the pair's nest has the best protection from rat snakes."

Today, foresters who manage for the survival of the red-cockaded woodpecker are obliged to deal with this resin-availability problem, he said. Although longleaf pines are still being planted, their slow growth rate—and the ever-increasing demand for developable land—make a return to the bird's heyday all but impossible.

Birds as Chemists?

Red-cockaded woodpeckers are truly picky birds. As it turns out, they may not just be looking for *volume* of resin when it comes to setting up housekeeping. It seems they're also concerned with quality.

One of the more interesting finds from Conner's "backyard" in eastern Texas is that the birds apparently have the ability to, in a sense, "analyze" the chemical composition of resin. He and his colleagues conducted a controlled experiment involving natural and artificial nesting cavities in stands of shortleaf and loblolly pines and found a strong preference among the birds for trees that contained resin with relatively high concentrations of diterpenes, a class of natural organic compounds.

"It appears as though the birds are selecting for trees with high levels of a particular diterpene complex," Conner said. "This complex seems to be related to the relative stickiness of the resin, which is related, of course, to the physical properties of resin flow."

Fussy or no, the cheerful, chatty little bird whose millions once graced the canopies of long-vanished forests shows signs of doing its best to adapt to its dramatically changed—and changing—environment. Research in Texas and elsewhere shows that the bird can survive in both shortleaf and loblolly ecosystems quite well, but does best in old longleaf pine forests, Conner says. This July, biologists and managers got the good news that the numbers of active red-cockaded woodpecker clusters (family groups of three birds or more) around the South have jumped by nearly 30 percent since 1994. In raw numbers, that's a rise from 4,694 woodpecker groups to 6,061.

"The loss of the past wide distribution of longleaf pine has been a major stumbling block for red-cockaded woodpeckers, but has not been the death of these birds," Conner said. "Artificial cavities have given us a second chance, a chance to restore the primary habitat needed to recover this endangered woodpecker."

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Frank Stephenson is a freelance science writer and editor of the Florida State University Research in Review.

A RARE SNAKE NEEDS GRASS, GOPHERS, AND FIRE TO SURVIVE

by Zoë Hoyle

You'll probably never see a Louisiana pine snake in the wild. Four to five feet long as an adult and covered with a striking pattern of black, brown, and beige, the snake is certainly noticeable. But it's been seen only a few times in the past two decades, by dedicated researchers like **Craig Rudolph** who are willing to spend thousands of hours looking for the elusive reptile.

Rudolph, a research ecologist with the **Southern Research Station unit in Nacogdoches, TX**, has spent more than a decade monitoring the decline of the Louisiana pine snake, which lives in the dwindling longleaf pine forests of east-central Texas and the western Louisiana Gulf Coastal Plain. The snake is already listed as threatened in Texas and is a candidate for listing under the Federal Endangered Species Act.

"The range of the Louisiana pine snake has contracted into a few isolated areas in Texas and Louisiana," says Rudolph. "The densest population we know of is on industrial forest land in Bienville Parish, Louisiana, where burning is used to reduce and manage the undergrowth."

Rudolph ties the reptile's disappearance to the huge loss of longleaf pine habitat and the suppression of fire in the habitat that remains. Fire is important to the pine snake: it shapes the sandy, well-drained longleaf pine savannas that support Baird's pocket gopher, the burrowing rodent that provides the snake with both food and shelter. Louisiana pine snakes feed on pocket gophers and live in their burrows—fewer gophers and burrows mean fewer pine snakes.

"Fire is critical to the longleaf pine ecosystem that the pine snake is dependent on," says Rudolph. "Periodic burning clears out the woody shrubs and promotes the growth of the bluestem grasses and other herbaceous plants the gopher feeds on."

"Less than three percent of the original longleaf pine savanna still stands," he adds. "The small fragments that do remain have been ecologically degraded by fire suppression."

In the late 1990s, Rudolph chose 77 locations in the known historical range of the Louisiana pine snake to assess for habitat quality. He found that many of these areas were too small to support a viable population of pine snakes; he found only 26 sites capable of providing habitat for the reptile.

"Unless we get lucky and trap one, we rarely encounter the pine snake above ground," says Rudolph. "They actually spend most of their lives in pocket gopher burrows or basking near a burrow entrance. If you find them active above ground, they're usually moving from one pocket gopher burrow system to another, using them to escape from predators and fire, or to hibernate."

Most of the longleaf pine forests in the pine snake's range were logged between 1870 and 1920. The land was converted to commercial pine plantations, where trees are grown very close together. This inhibits the growth of bluestem grasses, which lose out to shade or competition with woody plants as the plantation trees mature. Pocket gophers depend on the grasses for food. When the bluestem grasses die out, pocket gophers follow suit.

Adaptation May Not Lead to Survival

The Louisiana pine snake produces the largest eggs and hatchlings of any snake found in the United States, a trait which helps young snakes survive in good habitat conditions.

"The large size of the hatchlings may be an adaptation that allows the young to feed on gophers relatively early," says Rudolph. "The snake may have evolved this strategy in response to the low populations of small mammals in the Gulf Coastal longleaf pine savannas."

But this adaptation may also have contributed to the pine snake's decline. The snake's reproductive rate is relatively low—it lays only three to five eggs per clutch. If reduced to a few individuals, the species may be unable to recover quickly.

"We know less about the biology of the Louisiana pine snake than any other large snake in the United States," says Rudolph. "We have added to our knowledge by tracking the snakes we have found with radio-telemetry devices, but there is still much to learn."

Roads represent yet another danger. After assessing data on roadkills for the Angelina National Forest in east Texas, Rudolph and other Forest Service researchers found that moderate-to-high traffic can reduce populations of large snakes by 50 to 75 percent—and that the impact on snake populations can extend up to a half mile from the road. In one area surveyed for a 1999 study, 79 percent of the landscape lay within 745 yards of a highway or Forest Service road, well within this high-impact area.

Joining Together to Save a Snake

In March 2004, representatives of eight State and Federal agencies met at the Audubon Zoo in New Orleans to sign a landmark Candidate Conservation Agreement. The agreement protects the Louisiana pine snake on all Federal lands in Texas and Louisiana where the snake has been spotted. Some private timber companies are also interested in becoming a part of the agreement.

Under the agreement, Rudolph continues to monitor the snake in Texas and Louisiana, comparing trapping data to habitat quality in an attempt to answer the question: How marginal can the habitat get and still support snake populations?

There are six places still occupied by the pine snake—three small sites in Texas that are probably not large enough to maintain a viable population, and three larger areas in Louisiana. One of these larger areas is on the Fort Polk military base, where prescribed burning protects the snake's habitat.

On a practical level, monitoring means endless hours of trapping. "We are doing well at a site if we trap one Louisiana pine snake a year," says Rudolph. "On a good site and in the right season, it can take 400 trap days to catch one snake. On marginal sites, it can take several thousand trap days."

Rudolph says fire is imperative for viable pine snake populations.

"Without fire, these upland pine savanna ecosystems rapidly develop a woody mid-story that excludes the herbaceous plants needed by pocket gophers. It appears that when gopher populations decline, so do those of the pine snake. Prescribed burning is the only way to restore this habitat."

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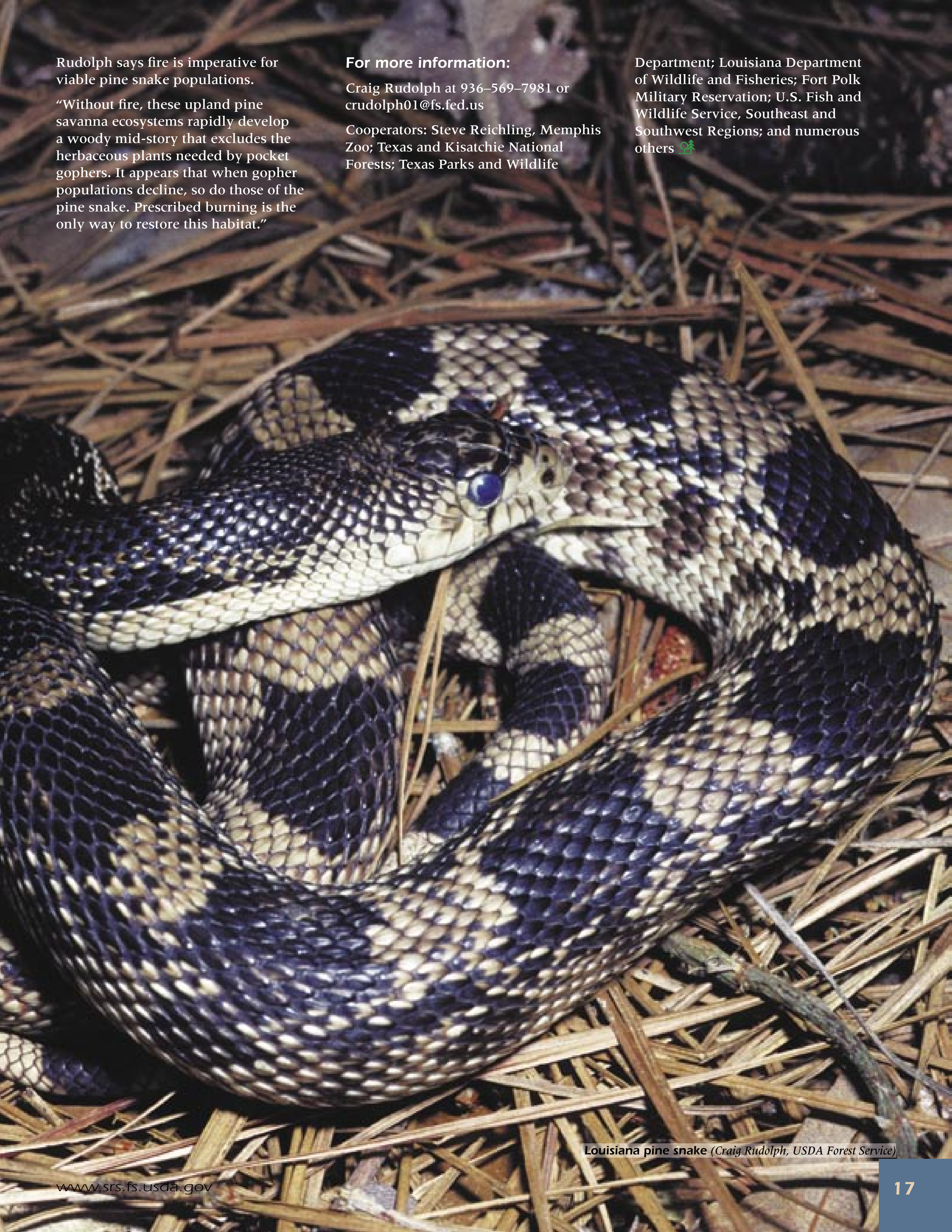
Cooperators: Steve Reichling, Memphis Zoo; Texas and Kisatchie National Forests; Texas Parks and Wildlife Department; Louisiana Department of Wildlife and Fisheries; Fort Polk Military Reservation; U.S. Fish and Wildlife Service, Southeast and Southwest Regions; and numerous others



Louisiana pine snake *(Craig Rudolph, USDA Forest Service)*

Restoring Longleaf in the Wake of the Southern Pine Beetle

by Zoë Hoyle

A native insect pest continues to rampage through the pines of the Southeast, leaving the green hills of summer splotched with brown. The southern pine beetle has damaged more than a million acres over the last decade, with economic losses estimated at $1.5 billion. With pine covering 60 percent of the 212 million acres of land in the South, more losses lie ahead.

"Even though southern pine beetle populations have declined since 2003, we estimate that 15 million acres of pines are still at moderate to high risk for infestation," says **John Nowak**, the Forest Health Protection entomologist who heads up the **Southern Pine Beetle Prevention and Restoration Program** initiated by the Forest Service in 2003.

The prevention part of the program represents a shift away from a reactive stance—suppressing beetle attacks as they arise—towards preventing attacks by applying forest management practices such as thinning to existing stands. Restoration addresses areas impacted by infestation, and consists of removing trees killed by southern pine beetle and replanting to restore the forest.

"Since most of the damage in the South is not on Forest Service land, we have to work through our Federal, State, and local partners to improve forest health," says Nowak. "One strategy is to replant longleaf pine, which is more resistant to southern pine beetle, in areas where the pest has destroyed loblolly and other pines."

The program works closely with the **Southern Research Station unit in Pineville, LA**, which conducts basic and applied research on the southern pine beetle and other invasive insects. Pineville scientists have been instrumental in describing the symbiotic relationship between the beetles and fungi that makes infestations even more destructive.

In 2004, project leader **Kier Klepzig** requested proposals for projects related to prevention and restoration activities. This call to action resulted in new work on restoration planning, genetic screening for resin traits tied to southern pine beetle resistance, and the development of genetic markers to track the insect's movements and population dynamics.

From Loblolly to Longleaf

Since 2003, the southern pine beetle prevention program has distributed almost $30 million to States and national forests across the Southeast, and over 100,000 acres of Federal, State, and private land have been treated. More than 100,000 additional acres were targeted for treatment by the end of 2005.

All 13 Southern States are involved in the prevention program to some extent, with 10 States providing cost-share funds to landowners for thinning or restoration. Most of the restoration projects are in the Eastern States of Georgia, Kentucky, North Carolina, South Carolina, and Tennessee where recent damage from the pine beetle has been most severe.

In Georgia, for example, last year's pine timber losses topped $57 million. Landowners saw their high-value loblolly pines killed in a matter of months by beetles, the value further reduced as the damaged timber flooded the market.

"Many of our landowners are wary of replanting in loblolly and facing the same situation in 10 or 20 years," says James Johnson, forest health coordinator with the Georgia Forestry Commission. "With funding from the prevention and restoration program, the Commission can offer them the opportunity to replant in longleaf pine on sites impacted by southern pine beetle."

The natural range of longleaf pine in Georgia has been documented well into the Piedmont area and as far northwest as the town of Rome. But Johnson stresses the importance of site quality when making the decision to plant.

Southern pine beetle in flight *(Erich G. Vallery, USDA Forest Service, www.forestryimages.org)*

"When we're helping landowners decide whether to replant in longleaf, we look for south facing slopes with well-drained soils," he says. "Seed source is also important. Seedlings planted in the Piedmont, where the term 'mountain longleaf' is often used, should come from a similar region."

More to Come

When trees fall prey to the southern pine beetle and lie dead on national forest floors, they become fuel for wildfire and undermine the habitat of threatened and endangered species like the red-cockaded woodpecker.

National forests in Kentucky, Mississippi, North Carolina, Tennessee, and Virginia are also involved in both prevention and restoration programs.

"A good example is the Bienville District in central Mississippi, where the National Forests of Mississippi are using prevention program funds to restore existing longleaf pine stands where loblolly pine has seeded in," Nowak says. "Forest technicians are removing all of the loblolly to restore the forest to only longleaf, and reducing the midstory to enhance red-cockaded woodpecker habitat."

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Cooperators: Southern Group of State Foresters, Forest Landowners Association, national forests and State agencies across the 13 States of the USDA Forest Service, Southern Region

Cost-Share Programs for Private Landowners

Since it was initiated in 2003, the **Southern Pine Beetle Prevention and Restoration Program** has distributed millions of dollars to the 13 States of the Southeast. Ten of these States provide cost-share funding to private landowners to thin forests or replant trees. Details of each State's program can be found at the following websites:

Alabama: http://www.forestry.state.al.us/Forest_Management/spb/spb_prevention_program.htm

Arkansas: http://www.forestry.state.ar.us/protect/protect.html#Insects

Florida: http://www.fl-dof.com/forest_management/fh_insects_spb_index.html

Georgia: http://www.gfc.state.ga.us/ForestManagement/spb.cfm

Louisiana: http://www.ldaf.state.la.us/divisions/forestry/default.asp

North Carolina: http://www.dfr.state.nc.us/health/health_spbpp.htm

South Carolina: http://www.state.sc.us/forest/id.htm

Tennessee: http://www.state.tn.us/agriculture/forestry/pinebeetle.html

Texas: http://texasforestservice.tamu.edu/shared/article.asp?DocumentID=900

Virginia: http://www.dof.virginia.gov/mgt/cip-fact-pbbp.shtml.

For general information about the program, see the Forest Health Protection website at http://www.fs.fed.us/foresthealth/programs/managing_natives.shtml

Restoring Native Longleaf Pine in Virginia

by Chris Asaro

When Captain John Smith landed in Jamestown in 1607, longleaf pine forests covered well over a million acres in southeastern Virginia. By the early 1800s, almost all of those forests were gone.

Although a few thousand longleaf pines still stand in Virginia, less than 500 are known to be genetically native, these located in marginal stands whose health is steadily declining.

Restoring longleaf pine is never easy. In healthy forests, seeds sprout quickly and seedlings thrive. But in marginal stands, longleaf pines often fail to bear enough cones to reproduce.

Bill Boyer, the retired Southern Research Station scientist known as "Mr. Longleaf" to fellow researchers, estimates that a longleaf stand needs to produce 360 cones per acre to get the first successful seedling. Cones average 50 seeds apiece, so natural regeneration requires at least 18,000 seeds per acre. In 2005, all the remaining native longleaf pine trees in Virginia together yielded only 1,241 viable seeds.

The lack of native seed and seedlings, combined with the diminishing quality of known native Virginia longleaf pine stands, make it essential that coordinated and thoughtful action be taken to protect and propagate remaining individuals.

The Virginia Departments of Forestry and Conservation and Recreation are working together to locate all the remaining native longleaf pine trees in the State, establish planting sites and easements, and purchase land to protect remaining native seed sources.

Over 500 seedlings have been started from native seeds at the forestry department's Garland Gray Nursery, and the department plans to graft another 900 trees for seed production and research. Researchers are also looking closely at longleaf pine genetics to determine how much effort to put into developing native Virginia sources, as opposed to using longleaf pine seeds and seedlings from nearby North Carolina.

Funding from the **USDA Forest Service, Southern Pine Beetle Prevention and Restoration Program** is providing

(continued on page 21)

CSI—Longleaf Pine!
In Virginia, Verifying the Tree's Original Range

by Tom Eberhardt and Phil Sheridan

Crime scene investigation shows are all the rage on TV these days. To determine the original range of longleaf pine in Virginia, we return to multiple "eco-scenes" to investigate the "remains" of very old southern yellow pine stumps. We use chemical and physical analyses in an effort to determine whether the wood samples collected from the stumps are actually longleaf pine. **Jolie Mahfouz,** biological technician with the Southern Research Station (SRS) **Bark Beetles and Invasive Insects unit** in Pineville, LA, adds another level of analysis with her expertise in gas chromatography and mass spectrometry.

Straight growth, coupled with strength and density, make longleaf pine highly desirable for poles, construction lumber, and flooring. Longleaf pine has a well-established history in naval stores production, from early turpentine operations to the subsequent processing of residual stumps, especially those from trees harvested in the late 19th and early 20th centuries.

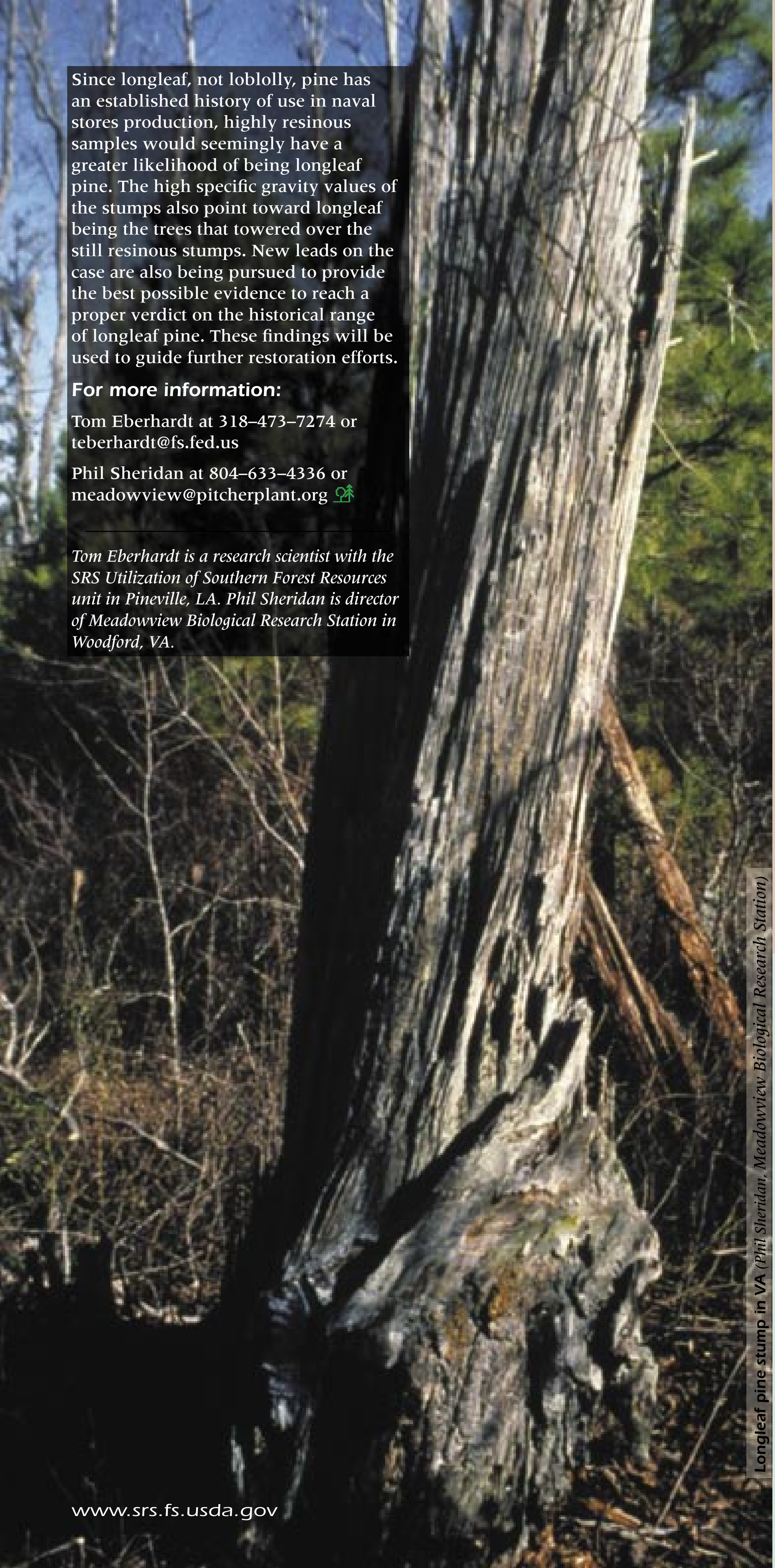
The range for longleaf pine spans from southeastern Virginia to eastern Texas. In Virginia, harvesting practices and changes in land use since colonial settlement have dramatically reduced the presence of longleaf pine. Of the original 1.5 million acres of longleaf forest estimated to exist in Virginia before colonial settlement, only 800 acres remain. Longleaf pine restoration efforts include studies designed to verify its range by determining the species of very old pine stump remnants. Since wood structure cannot be used to differentiate between the southern yellow pines, the objective was to assess whether chemical and physical differences could be used for species identification.

We collected highly weathered fragments from stump remnants located in Caroline, Southampton, and Sussex Counties in eastern Virginia. Wood shavings were obtained using an electric drill to put holes into retrieved stump fragments. Mahfouz then analyzed sample extracts using gas chromatography coupled with mass spectrometry. This technique separates an extract into its components, allowing the collection of mass spectra that, like fingerprints, can be compared to a database for identification. We also used small wood blocks cut from the samples to determine wood densities. The greatest obstacle to the investigation was the lack of well-characterized stump samples for comparison. Only recently has the study of old stumps become important.

We think the stumps we have sampled are longleaf or loblolly pine, based on species identification signatures. Despite their age, the stumps have retained their resinous quality. Examining the gummy wood shavings revealed significant amounts of monoterpenes, the substances found in the oleoresins of conifers used to make solvents and other products. The most abundant monoterpene in both longleaf and loblolly pines is pinene. Turpentine has a minimum pinene content of 40 percent by weight. Distilled from pine oleoresin or pine wood, turpentine can be used as a solvent to thin oil paints and make varnishes.

The stump sample from Sussex County was particularly interesting because it showed an even greater degree of monoterpene oxidation. This could be the result of high temperatures from forest fires. In fact, burn scars on the Sussex County sample indicate the exposure to fires that one would expect in a longleaf pine ecosystem. Since pond pine has a very low concentration of pinene, lower than that found in the stumps, we excluded it from consideration. The tree stumps could not be the remains of slash pines because that species' range does not extend as far north as Virginia.

Finally, consider the evidence of specific gravity, a measure of the amount of wood substance per unit volume, essentially meaning wood density. Specific gravity values for loblolly pine are lower than those for longleaf pine. The specific gravity values for the samples we took were significantly higher than those reported in the literature and reflect the very resinous nature of the samples. These results show that specific gravity, which can be easily measured in the field by determining the size and weight of a specimen, could be an alternative to extractions requiring solvents and laboratory facilities.



Longleaf pine stump in VA (Phil Sheridan, Meadowview Biological Research Station)

Since longleaf, not loblolly, pine has an established history of use in naval stores production, highly resinous samples would seemingly have a greater likelihood of being longleaf pine. The high specific gravity values of the stumps also point toward longleaf being the trees that towered over the still resinous stumps. New leads on the case are also being pursued to provide the best possible evidence to reach a proper verdict on the historical range of longleaf pine. These findings will be used to guide further restoration efforts.

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Restoring Native Longleaf Pine

(continued from page 20)

cost-share for landowners interested in planting and establishing native longleaf pine, as well as supporting the basic costs of pollination and grafting, collecting seed, and protecting native trees from seed and cone insects. The Virginia Department of Forestry is exploring the possibility of hiring a full-time restoration forester, whose salary would be supported in part by Federal funds.

Future priorities for the project include:

- Joining the Longleaf Alliance
- Identifying additional nonprofit and university collaborators
- Mapping and protecting locations of all known native longleaf pines
- Increasing seedling production capacity towards producing at least 50,000 containerized longleaf pine from native Virginia sources
- Planting over 500 acres or more of native longleaf every year

For more information:

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Chris Asaro is forest health specialist with the Virginia Department of Forestry.

Naval Stores

In the past, pine tar and pitch were used extensively on sailing ships to caulk seams and to protect ropes. No ship left port without an essential store of tar and pitch. These pine products are still referred to as naval stores, but they now have far different uses. Today, the chemical products from pine trees—turpentine, resin, and fatty acids—are used to manufacture inks, adhesives, perfumes, and hundreds of other consumer products. There are three ways of obtaining these chemical raw materials from pines. They can be produced as a byproduct of the process used to manufacture paper from pines; extracted from pitch-soaked stumps; or obtained by tapping live trees.

Restoring Longleaf Pine

The Longleaf Alliance

http://www.longleafalliance.org/

The Longleaf Alliance was established in 1995 with the express purpose of coordinating a partnership between private landowners, forest industries, State and Federal agencies, conservation groups, researchers, and others interested in managing and restoring longleaf pine forests. The alliance serves as a clearinghouse for information, provides networking opportunities for over 700 members, and coordinates technical meetings and education seminars.

The Nature Conservancy

http://www.nature.org/

The Nature Conservancy (TNC) has identified the longleaf pine ecosystem as a conservation priority. In 2002, TNC began managing the **Greenwood Plantation** (http://nature.org/success/greenwood.html) in Thomas County, GA. The 5,200-acre plantation includes a 1,000-acre section of old-growth longleaf pine known as the "Big Woods." TNC also works to protect remaining tracts of longleaf pine across its original range by educating landowners, helping to set up and manage conservation easements, and purchasing land.

The Joseph W. Jones Ecological Research Center

http://www.jonesctr.org/

Located at Ichauway, a plantation established by Robert W. Woodruff in 1929 in Baker Country, GA, the center focuses on questions related to the restoration of longleaf pine ecosystems, conservation biology of rare species, and management of mature longleaf pine woodlands. An outdoor laboratory used for research, conservation, and restoration of regional ecosystems, Ichauway includes 17,000 acres of mature longleaf pine forest. Outreach activities include field demonstrations and workshops on prescribed fire, sustainable management, and the ecological restoration of threatened ecosystems and wildlife habitat.

Tall Timbers Research Station

http://www.talltimbers.org/

The mission of Tall Timbers Research Station, located in Tallahassee, FL, is to foster exemplary land stewardship through research, conservation, and education. Established in 1958 as a nonprofit ecological research station, Tall Timbers has played a critical part in fire ecology research. Tall Timbers' conservation efforts are dedicated to helping protect the distinctive Red Hills landscape of south Georgia and north Florida.

U.S Fish and Wildlife Service (USFWS)

http://www.fws.gov/southeast/partners/pfwpine.html

The USFWS, Southeast Region, through its Partners for Fish and Wildlife Program, works with partners to locate private landowners interested in restoring the longleaf pine ecosystem, and to develop and carry out a habitat restoration plan for their property. Over the past five years, USFWS has initiated habitat restoration projects on over 18,000 acres (100+ landowners) in Georgia, North and South Carolina, Alabama, and Florida.

USFWS Safe Harbor Program

http://www.fws.gov/endangered/recovery/harborqa.pdf

Started to aid the recovery of the red-cockaded woodpecker in the North Carolina Sandhills, the Safe Harbor Program works with private landowners to improve habitat for endangered and threatened species. To become a Safe Harbor Forest, the landowner works with the USFWS to determine a set number of the endangered or threatened species that will be maintained on the property as habitat is improved. In exchange for this voluntary cooperation, the landowner is assured that no future restrictions on land use will be imposed. Since the first agreement was signed in 1995, over half a million acres have been enrolled in red-cockaded woodpecker Safe Harbor agreements.

USDA Forest Service Forest Legacy Program

http://www.fs.fed.us/spf/coop/programs/loa/flp.shtml

The Forest Legacy Program (FLP) supports State efforts to protect environmentally sensitive forest lands. To maximize the public benefits it achieves, the program focuses on the acquisition of partial interests in privately owned forest lands. FLP encourages and supports acquisition of conservation easements, legally binding agreements transferring a negotiated set of property rights from one party to another, without removing the property from private ownership. Most FLP conservation easements restrict development, require sustainable forestry practices, and protect other values.

USDA Forest Service Southern Region, Forest Stewardship Program

http://www.fs.fed.us/r8/spf/coop/stewardship/

Forest stewardship programs are delivered at the State level through the State Forester's office, and include assistance with conserving or improving resources. Nonindustrial private landowners can work with foresters to develop an integrated forest management plan that can include ecological restoration activities.

Landowner's **TOOLBOX**

RECOMMENDED READING

Crowning Glory

Brockway, D.G.; Outcalt, K.W.; Guldin, J.M. [and others] 2005. **Uneven-aged management of longleaf pine forests: a scientist and manager dialogue.** Gen. Tech. Rep. SRS–78. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 38 p. http://www.srs.fs.usda.gov/pubs/9636. [Date accessed: September 6, 2005].

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There's More to Restoration than Planting Trees

Walker, J.L. 1998. **Ground layer vegetation in longleaf pine landscapes: an overview for restoration and management.** In: Proceedings of symposium on restoration and regional conservation strategies. Longleaf Alliance Rep. 3. Auburn, AL: Auburn University: 2-14.

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What Lies Beneath

Cohen, S.; Braham, R.; Sanchez, F. 2004. **Seed bank viability in disturbed longleaf pine sites.** Restoration Ecology. 12(4): 503-515.

Measuring Restoration at the Ground Level

Silletti, A.M.; Walker, J.L. 2003. **Adaptive cluster sampling: an efficient method for assessing inconspicuous species.** Ecological Restoration. 21(4): 330-331. http://www.srs.fs.usda.gov/pubs/9876. [Date accessed: September 6, 2005].

A Resin for Being

Conner, R.N.; Johnson, R.H.; Rudolph, D.C.; Saenz, D. 2003. **Do red-cockaded woodpeckers select cavity trees based on chemical composition of pine resin?** Wilson Bulletin. 115(4): 397-402. http://www.srs.fs.usda.gov/pubs/6998. [Date accessed: September 6, 2005].

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A Rare Snake Needs Grass, Gophers, and Fire to Survive

Rudolph, D.C.; Burgdorf, S.J. 1997. **Timber rattlesnakes and Louisiana pine snakes of the west Gulf Coastal Plain: hypotheses of decline.** Texas Journal of Science. 49(3) Suppl.: 111-122. http://www.srs.fs.usda.gov/pubs/537. [Date accessed: September 6, 2005].

Rudolph, D.C; Burgdorf, S.J.; Conner, R.N.; [and others]. 2002. **Prey handling and diet of Louisiana pine snakes *(Pituophis ruthveni)* and black pine snakes *(P. melanoleucus lodingi)*, with comparisons to other selected colubrid snakes.** Herpetological Natural History. 9(1): 57-62. http://www.srs.fs.usda.gov/pubs/6219. [Date accessed: September 6, 2005].

Animals Adapted to a Disappearing Habitat

Engstrom, R.T.; Kirkman, L.K.; Mitchell, R.J. 2001. **Natural history: longleaf pine-wiregrass ecosystem. In: The fire forest: longleaf pine-wiregrass ecosystem.** Covington, GA: Georgia Wildlife Press: 16-17. http://www.sherpaguides.com/georgia/fire_forest/natural_history/index.html. [Date accessed: September 6, 2005].

Restoring Longleaf in the Wake of Southern Pine Beetle

Moorehead, D.J.; Bargaron, C.T.; Douce, G.K. [N.d.]. **Stand visualization for southern pine beetle management and decision making: a visual guide for managing existing pine stands.** [Athens, GA]: University of Georgia, The Bugwood Network. http://www.barkbeetles.org/standvisual/. [Date accessed: September 6, 2005].

Scientific Names of Featured Organisms

Trees

Longleaf pine (*Pinus palustris*)

Loblolly pine (*P. taeda*)

Slash pine (*P. elliottii*)

Shortleaf pine (*P. echinata*)

Grasses

Wiregrass (*Aristida* spp.)

Bluestem (*Andropogon* spp., *Schizachyrium* spp.)

Panic grass (*Dichanthelium* spp.)

Composites

Asters (*Symphiotrichum* spp., *Sericocarpus* spp., *Eurybia* spp.)

Black-eyed Susan (*Rudbeckia hirta*)

Blueberry (*Vaccinium* spp.)

Bonesets (*Eupatorium* spp.)

Goldenrod (*Solidago* spp.)

Ironweed (*Vernonia angustifolia*)

Liatris (*Liatris* spp.)

Sunflowers (*Helianthus* spp.)

Legumes

Beggarweeds (*Desmodium* spp.)

Dollar leaf (*Rhyncosia reniformis*)

Goat's rue (*Tephrosia virginiana*)

Lespedezas (*Lespedeza* spp.)

Milkpeas (*Galactia* spp.)

Ferns

Bracken fern (*Pteridium aquilinum*)

Carnivorous Plants

Venus' flytrap (*Dionaea muscipula*)

Yellow pitcher plant (*Sarracenia flava*)

Insects

Southern pine beetle (*Dendroctonus frontalis*)

Birds

Red-cockaded woodpecker (*Picoides borealis*)

Snakes

Louisiana pine snake (*Pituophis ruthveni*)

Rat snakes (*Elaphe obsoleta* spp.)

Longleaf pine stand viewed through fog *(Bill Lea, USDA Forest Service, retired)*

Since the 1920s, the USDA Forest Service has maintained a system of experimental forests to test hypotheses and collect long-term data about the ecological effects of fire, grazing, insect infestations, air pollution, and other disturbances. In the South, researchers from Federal agencies and universities use 15 active experimental forests for studies ranging from the practices needed to maintain healthy forests, to the water filtration functions of forests, to habitat restoration for endangered species.

Experimental forests are some of the few places in the United States where long-term data are collected about forests and how they change over time. These living laboratories also serve as demonstration sites where cooperators and landowners can see the results of different forest management options.

Palustris Experimental Forest *(Jim Barnett, USDA Forest Service)*

WHAT CAN EXPERIMENTAL FORESTS TEACH US ABOUT LONGLEAF PINE RESTORATION?

In 1935, the USDA Forest Service established the 7,500-acre **Palustris Experimental Forest** as a research study plot on the Kisatchie National Forest. The Palustris was representative of the surrounding territory in central and southwestern Louisiana and east Texas: it had once supported magnificent longleaf pine stands, many of which were destroyed by railroad and cable logging in the early part of the century. Later attempts to farm on the shallow, poorly drained soil had failed, and many of the longleaf stands were left barren or invaded by scrub oaks and other undesirable hardwoods.

Early research on the Palustris concentrated on finding methods to reforest the cutover land, first by introducing loblolly and slash pines and later by reestablishing the more disease-, fire-, and storm-resistant longleaf pines. On stands that lacked the remnants of a longleaf ecosystem to shelter and nurture young trees, researchers transplanted nursery-grown bare-root seedlings and then tested different treatment combinations to help them survive until their roots could recover.

Although somewhat effective, planting bare-root seedlings proved to be more labor intensive and expensive than was practical for landowners with large acreages of cutover land, so new experiments began on direct seeding. This research resulted in guidelines for site and seedbed preparation, ideal timing for sowing, quantity and quality standards for seeds, and methods to protect against losses to birds and grazing animals.

As the stands in the experimental forest grew from the seedling to sapling stage, researchers tested longleaf growth responses to thinning and pruning, and the effectiveness of prescribed burning in reducing competition from faster growing trees. Responding to landowner needs for income production on the slow-growing longleaf acreage, they introduced grazing on some plots and measured both the seasonal weight gains of the cattle and the ecological effects on the trees.

Today, visitors to the Palustris can see 80-year-old longleaf pine stands that demonstrate the long-term effects of various treatments and planting methods, including the newest study results on container-grown seedlings. Ecophysiology studies are underway with Louisiana State University faculty to understand relationships between tree physiology and belowground processes. These studies will provide tools that will help landowners manage their longleaf stands to mitigate the effects of global change.

Again, responding to landowner needs and recognizing that pine straw has more potential for income than timber, researchers have begun testing the effects of alternative pine straw harvesting methods on soil and stand productivity. Their goal is to develop guidelines for maximizing income while maintaining productive and healthy longleaf stands.

Across the South, private landowners are expressing renewed appetite for the aesthetic and wood-quality values of the more difficult to establish longleaf pines. They will find that the Palustris Experimental Forest is an excellent repository of practical information, and that it serves as a living reminder that longleaf restoration is both possible and worth the effort.

Palustris Experimental Forest:
http://www.srs.fs.usda.gov/4111/

For more information:
James Haywood at 318–473–7226 or dhaywood@fs.fed.us.

DANNY LEE SEEKS HELP TO MANAGE FOREST THREATS

by Claire Payne

Danny Lee, director of the recently established **Eastern Forest Environmental Threat Assessment Center**, grew up a couple of hours from Asheville in Sevier County, TN. He has come back East to tackle threats prioritized by the USDA Forest Service Chief Dale Bosworth: loss of open space, invasive plants, unmanaged recreation, and fire and fuels, as well as forest pests, disease, pollution, and natural disturbances such as hurricanes. Lee says learning how the Forest Service can best address these and other issues will make for very interesting collaboration with colleagues and partners.

"I like the integrative nature of the work," he says. "The dynamics of bringing people to the table with their separate interests, expertise, and ideas are very challenging."

With Lee at the helm, the center will focus initially on establishing connections and partnerships, funding technology development, and producing synthesized papers to share information. "Managers and researchers at large know the issues well, but can benefit from advances in technology," says Lee. "We can help provide the tools they need." He looks forward to building relationships with people who will bring their ideas and knowledge to participate in problem solving.

One way to link people is to introduce practitioners to monitoring and research personnel so together they can detect situations in the field. Lee plans for the center to deliver scientific information in an accessible manner. "Many people don't have time to read and analyze scientific literature. We want to provide portals to tools and information that people need in a form that is organized and coherent," he says.

Lee wants to enhance the activities of others. "We're in a fluid state now, soliciting and integrating people's ideas and identifying clients," he says. "We plan to add staff that can help foster partnerships and deliver a mix of products. Our first goal is to determine what the center can do early on to meet some needs in a timely and responsive manner."

"We're also going to begin working on long-term projects, some of which will require a 3- to 10-year timetable," he adds. "We want to provide leverage for the good ideas of others. We can help others get connected and bring their ideas to market."

Experimental Forests

1	Bent Creek	NC
2	Blue Valley	NC
3	Coweeta	NC
4	John C. Calhoun	SC
5	Santee	SC
6	Scull Shoals	GA
7	Hitchiti	GA
8	Olustee	FL
9	Chipola	FL
10	Escambia	AL
11	Tallahatchee	MS
12	Delta	MS
13	Harrison	MS
14	Palustris	LA
15	Stephen F. Austin	TX
16	Crossett	AR
17	Alum Creek	AR
18	Sylamore	AR
19	Henry F. Koen	AR

Evolution of a Leader

Before Lee joined the Forest Service, he earned an undergraduate degree in zoology and a master's degree in ecology from the University of Tennessee, as well as a master's in applied statistics from Louisiana State University. While a graduate student, Lee worked primarily with fish. For his first research project, Lee counted and measured growth rings—similar to tree rings—in the pectoral spines of catfish collected in the Mississippi River. He later modeled native trout populations in the Great Smoky Mountains National Park. Lee earned his Ph.D. from Texas A&M University while working for Resources for the Future, a nonprofit research institute in Washington, DC, modeling the effects of the Federal hydropower system on anadromous fishes in the Pacific Northwest's Columbia River Basin. Lee joined the Forest Service's Intermountain Research Station in 1991 to work with fish populations in Boise, ID.

Lee's Forest Service career includes work in California and the Northwest, where he worked on the Interior Columbia River Ecosystem Management Plan and the Pacific Northwest Forest Plan. He also worked on the Sierra Nevada Framework for Conservation and Collaboration, a joint effort between Forest Service Research and Development, the National Forest System, and other State and Federal partners designed to guide management of 11 national forests in California. Lee managed the science integration team that supported an interdisciplinary team charged with developing management alternatives for the Sierra Nevada forests.

In 2000, Lee became project leader of the Pacific Southwest Research Station's Timber Management/Wildlife Interactions unit in Arcata, CA, which is distinguished by its work on sensitive birds, amphibians, and mammals, including spotted owls, marbled murrelets, fishers, and martens. Interestingly, the Klamath-Siskiyou area in northern California is second only to the Southern Appalachians in terms of diversity of amphibians and reptiles on the North American continent, and first in diversity of conifers.

While in Arcata, Lee formed a group that developed tools for assessing the risks of landscape-level fuel reductions or postfire treatment effects on fish and wildlife. "Forest thinning can affect multiple species both positively and negatively," says Lee. "Although we may have some information on the immediate effects of forest thinning on fish and wildlife at the stand level, we are less certain of the larger scale or longer term impacts." Lee and his colleagues developed a framework and a set of tools for fire risk assessment that evaluates tradeoffs among different risks and values, including fish and wildlife. The resulting Comparative Risk Assessment Framework and Tools Program uses the building blocks of ecological risk assessment, decision analysis, and decision protocols.

Setting a Course

Lee believes public involvement and transparency in planning are essential to reaching solutions. "It's not wise to fall into the trap of planning only for the more probable outcomes and ignoring those with little chance of occurring—especially if the low-probability events have disastrous consequences. The tragic events following Hurricane Katrina are a graphic reminder of the necessity for planning for the extremes. Risk is a value laden concept," Lee says. "Whose values are threatened if a certain course of action is prescribed? We need to put options on the table, anticipate where problems might arise, and honestly evaluate the tradeoffs."

"At the landscape scale, there are no simple problems," he continues. "We need to consider wildland development and changing and conflicting attitudes about how forest lands—public and private—are managed. We need to identify the factors that engage people, define what matters, develop clear objectives, and target activities to meet those objectives."

Public participation matters to Lee. "The entire process must involve the public and be transparent," he says. "Regardless of management choices, there are multiple possible outcomes; nothing is guaranteed. People may desire certainty from the government, but they respect the truth more. We need to rigorously portray what we know and don't know. Reducing uncertainty costs something in the realm of tradeoffs. What are you willing to live with? If none of the options presented are acceptable, that's a great incentive for new thinking."

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Errata...

The Spring 2005 issue of *Compass* incorrectly attributed the cover photo to John Asher, USDI, Bureau of Land Management, while the photo was actually taken by Bill Kline, Dow AgroSciences. Additionally, the photographs used in the Spring 2005 issue of *Compass*, except for those on pages 4, 6, 8, 20, 24, 30, and rear cover should have been attributed to *www.forestryimages.org*. The editorial staff regrets this omission.

What Was It?

A Louisiana pine snake appeared on the back cover of the Spring 2005 issue of *Compass*. Bruce Thacker, Senior Research Technician at the Ministry of Natural Resources in Thunder Bay, Canada, responded with the correct answer. He will receive a framed, first-edition poster of *Nonnative Invasive Plants of the South*, currently in production.

SRS Headquarters, Asheville, NC *(Rodney Kindlund, USDA Forest Service)*

NEW PRODUCTS

Southern Pine Ecosystems

1 Barnett, James P.; McGilvray, John M. 1997. **Practical guidelines for producing longleaf pine seedlings in containers.** Gen. Tech. Rep. SRS-14. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 28 p.

Longleaf pine, although widely distributed in the presettlement forests of the southern Coastal Plain, now occupies less than 10 percent of its original range. It is a highly desirable species because it resists fire, insects, and disease and produces excellent quality solid-wood products. Regeneration of the species either by natural methods or by planting of bare-root nursery stock has been difficult, and renewed interest in it has resulted in evaluation of new approaches to seedling establishment. Using container stock has greatly improved the success of longleaf pine establishment. Practical guidelines are presented that will help nursery personnel consistently produce good container stock that will survive well and initiate early height growth.

2 Barnett, James P.; McGilvray, John M. 2002. **Guidelines for producing quality longleaf pine seeds.** Gen. Tech. Rep. SRS-52. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 21 p.

Longleaf pine *(Pinus palustris)* seeds are sensitive to damage during collection, processing, treatment, and storage. High-quality seeds are essential for successfully producing nursery crops that meet management goals and perform well in the field. Uniformity in the production of pine seedlings primarily depends on prompt and uniform seed germination, early seedling establishment, and a variety of cultural practices that are applied as the seedlings develop. The best collecting, handling, and processing methods maximize performance attributes and reduce the need for extensive nursery cultural practices to compensate for poor seed quality. Guidelines are presented that will help seed dealers, orchard managers, and nursery personnel produce high-quality longleaf pine seeds and improve the efficiency of nursery production.

3 Brockway, Dale G.; Outcalt, Kenneth W.; Guldin, James M. [and others]. 2005. **Uneven-aged management of longleaf pine forests: a scientist and manager dialogue.** Gen. Tech. Rep. SRS-78. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 38 p.

Although longleaf pine can be managed using even-aged techniques, interest in uneven-aged methods has grown significantly as a result of concern for sustaining the wide range of ecological values associated with maintaining continuous crown cover in these ecosystems. Scientists from the U.S. Department of Agriculture, Forest Service, Southern Research Station and faculty members from the School of Forest Resources and Conservation at the University of Florida engaged in a dialogue focused on: (1) methods for converting even-aged to uneven-aged stands; (2) growth and yield; (3) selection harvest techniques; (4) optimum logging practices; (5) effects on red-cockaded woodpeckers; (6) prescribed burning approaches; (7) regeneration; (8) optimum stand structure; (9) competition tolerance and release of various seedling age classes; and (10) viability of interplanting and underplanting.

4 Brockway, Dale G.; Outcalt, Kenneth W.; Tomczak, Donald J.; Johnson, Everett E. 2005. **Restoration of longleaf pine ecosystems.** Gen. Tech. Rep. SRS-83. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 34 p.

Longleaf pine *(Pinus palustris)* ecosystems once occupied 38 million ha in the Southeastern United States, occurring as forests, woodlands, and savannas on a variety of sites ranging from wet flatwoods to xeric sandhills and rocky mountainous ridges. Timber harvest, land conversion to agricultural and other nonforest uses, and alteration of fire regimes greatly reduced longleaf pine ecosystems, until only 1.2 million ha remained in 1995. Restoration efforts now underway use physical, chemical, and pyric methods to reestablish natural structure and function in these ecosystems. Benefits of restoration include expanding and improving habitat available to aid in the recovery and sustainability of numerous species; producing greater amounts of high-quality longleaf pine timber products; increasing the production of pine straw; providing new recreational opportunities; preserving natural and cultural legacies; and creating a broader range of management options for future generations.

5 Grell, Adrian G.; Shelton, Michael G.; Heitzman, Eric. 2005. **Changes in plant species composition along an elevation gradient in an old-growth bottomland-*Pinus taeda* forest in southern Arkansas.** Journal of the Torrey Botanical Society. 132(1): 72-89.

Old-growth bottomland hardwood-*Pinus taeda* forests are rare in Arkansas, and the complex relationships between plant communities and environmental conditions have not been well described. To investigate these relationships, a digital elevation model was developed for a 16.2 ha old-growth bottomland hardwood-*Pinus taeda* forest in southern Arkansas. Overstory trees, saplings, seedlings, and herbaceous plants were analyzed in three 0.5 m elevation classes and by using indirect gradient analysis. Information was also collected on site factors, soil physical factors, soil moisture, and soil chemical factors. Results from this study suggest that differences in vegetation were primarily the result of subtle elevation variations. Restoration or management of these forests should carefully consider microtopographical influences.

6 Hofstetter, R.W.; Mahfouz, Jolie B.; Klepzig, Kier D.; Ayres, M.P. 2005. **Effects of tree phytochemistry on the interactions among endophloedic fungi associated with the southern pine beetle.** Journal of Chemical Ecology. 31(3): 539-560.

We examined the interaction between host trees and fungi associated with southern pine beetle. We evaluated the response of four pine species to fungal invasion and effects of plant secondary metabolites on primary growth of and secondary colonization of three fungi. Size of lesions formed and quantity of secondary metabolites produced in response to fungal inoculations varied significantly. Growth rates of mycangial fungi increased in the presence of several secondary metabolite volatiles. Phloem phytochemistry altered relative fungal growth and competitiveness. Host-mediated interactions among these fungi have important consequences for population dynamics of southern pine beetle.

7 Johnsen, K.; Maier, C.; Kress, L. 2005. **Quantifying root lateral distribution and turnover using pine trees with a distinct stable carbon isotope signature.** Functional Ecology. 19: 81-87.

To help assess spatial competition for below-ground resources, we quantified the effects of fertilization on root biomass quantity and lateral root distribution of mid-rotation *Pinus taeda* trees. Using open-top chambers, individual trees were provided CO^2 depleted in ^{13}C relative to the atmosphere. The ^{13}C:^{12}C label allowed us to partition root biomass from soil cores into a fraction derived from individual chamber trees and that derived from non-chamber trees within the stand. Using a mixing model, we calculated that 0-2 mm roots had a mean residence time of 4½ years, indicating relatively slow fine-root turnover, a result that has major implications in modeling C cycling.

8 Klepzig, Kier D.; Robison, Daniel J.; Fowler, Glenn. [and others]. 2005. **Effects of mass inoculation on induced oleoresin response in intensively managed loblolly pine.** Tree Physiology. 25: 681-688.

Oleoresin flow is an important factor in the resistance of pines to attack by southern pine beetle and its associated fungus *Ophiostoma minus*. Abiotic factors, such as nutrient supply and water relations, have the potential to modify this plant–insect–fungus interaction; however, little is known of the effects of inoculation with this bluestain fungus on oleoresin flow. Mass inoculation with *O. minus* resulted in a significant, long-lived, induced resin response in loblolly pine. Despite mass inoculations, however, *O. minus* did not kill the host trees, suggesting that this fungus is not a virulent plant pathogen.

9 Kopper, Brian J.; Illman, Barbara L.; Kersten, Philip J. [and others]. 2005. **Effects of diterpene acids on components of a conifer bark beetle-fungal interaction: tolerance by *Ips pini* and sensitivity by its associate *Ophiostoma ips*.** Environmental Entomology. 34(2): 486-493. [Editor's note: Southern Station scientist Kier Klepzig co-authored this publication.]

Conifer resin and phloem tissue contain monoterpenes, diterpene acids, and stilbene phenolics. We tested three red pine diterpene acids on the bark beetle *Ips pini*, and its fungus *Ophiostoma ips*. No diterpene acid affected the host-acceptance behavior or larval survival of *Ips pini*. Abietic acid and isopimaric acid strongly inhibited spore germination of *O. ips*, and abietic acid strongly inhibited mycelial growth. Conifer defenses against bark beetle fungal complexes are multifaceted, with all three phytochemical groups being important to red pine, but each with varying relative activity against the beetles and fungi that attack it.

10 Kubisiak, Thomas L.; Amerson, Henry V.; Nelson, C. Dana. 2005. **Genetic interaction of the fusiform rust fungus with resistance gene Fr_1 in loblolly pine.** Phytopathology. 95: 376-380.

We propose a method for defining DNA markers linked to *Cronartium quercuum* f. sp. *fusiforme* avirulence genes. Results of this study suggest that multiple infections within a single gall are common using the concentrated basidiospore system. Roughly 57 percent of the drops harvested were found to consist of more than one haploid genotype, most likely due to the physical mixing of spores from genetically different pycnia. Most importantly, although multiple infections do occur in the formation of a single gall, no evidence suggests that the genetics of the proposed gene-for-gene interaction are compromised.

11 Outcalt, Ken. 2000. **The longleaf pine ecosystem of the South.** Native Plants Journal. 1(1): 42-44, 47-53.

Longleaf pine (*Pinus palustris* [Pinaceae]) was the most prevalent pine type in the Southern United States. Stands of longleaf were also habitat for a vast array of plant species. Decades of timber harvest, followed by conversion to agriculture, urban development, or to other pine species, have reduced longleaf-dominated areas to less than 5 percent of its original range. This paper discusses the habitat and history of this once vast resource, outlining its key role as an integral part of native plant communities. I also focus on the more recent recognition of the ecological importance of longleaf pine ecosystems.

12 South, David B.; Harris, Sandy W.; Barnett, James P. [and others]. 2005. **Effect of container type and seedling size on survival and early height growth of *Pinus palustris* seedlings in Alabama,** *U.S.A.* Forest Ecology and Management. 204(2) 385-398

Three hard-wall container types, one styroblock® container type, and two mesh-covered plugs were used to grow longleaf pine *(Pinus palustris)* seedlings at a nursery in Louisiana. In 2001, these container types, along with bare-root seedlings (from a different seed source), were outplanted on two old-field sites and two cutover sites. There were significant site-by-treatment interactions. A root bound index (RBI) was developed and was calculated for each container seedling by dividing root-collar diameter by the diameter of the container cell. Survival was low when RBI was greater than 27 percent. Although large-diameter bare-root stock can be advantageous as far as survival and growth are concerned, the same may not be true for containers. Some 7-month old container seedlings might become too large for some container types.

13 Ulyshen, Michael D.; Hanula, James L.; Horn, Scott. 2005. **Using Malaise traps to sample ground beetles (Coleoptera: Carabidae).** Canadian Entomologist. 137: 251-256.

Pitfall traps provide an easy and inexpensive way to sample ground-dwelling arthropods and have been used exclusively in many studies of the abundance and diversity of ground beetles *(Coleoptera: Carabidae)*. However, pitfall traps often fail to collect both small and "trap-shy" species, eventually deplete the local carabid population, require a species to be ground-dwelling to be captured, and produce different results depending on trap diameter and material, type of preservative used, and trap placement. Further complications arise from seasonal patterns of movement among beetles, numerous climatic factors, differences in plant cover, and variable surface conditions. We demonstrate the effectiveness of Malaise traps for sampling ground beetles in a bottomland hardwood forest.

Wetlands, Bottomlands, and Streams

14 Richter, Stephen C.; Young, Jeanne E.; Siegel, Richard A.; Johnson, Glen N. 2001. **Postbreeding movements of the dark gopher frog, *Rana sevosa* Goin and Netting: implications for conservation and management.** Journal of Herpetology. 35(2): 316-321.

Conservation plans for amphibians often focus on activities at the breeding site, but for species that use terrestrial habitats for much of the year, an understanding of nonbreeding habitat use is also essential. We used radio telemetry to study the postbreeding movements of individuals of the only known population of dark gopher frogs, *Rana sevosa*, during two breeding seasons. Movements away from the pond were relatively short and usually occurred within a two-day period after frogs initially exited the breeding pond. Dispersal distances for some individuals may have been constrained by a recent clearcut on adjacent private property. When implementing a conservation plan for *Rana sevosa* and other amphibians with similar habitat utilization patterns, we recommend that a terrestrial buffer zone of protection include the aquatic breeding site and adjacent nonbreeding season habitat.

15 Strayer, David L.; Downing, John A.; Haag, Wendell R. [and others]. 2004. **Changing perspectives on pearly mussels, North America's most imperiled animals.** Bioscience. 54(5): 429-439.

Pearly mussels (Unionacea) are widespread, abundant, and important in freshwater ecosystems around the world. Catastrophic declines in populations have led to research on mussel biology, ecology, and conservation. Research has begun to benefit from and contribute to ideas about suspension feeding, life history theory, metapopulations, flow refuges, spatial patterning and its effects, and management of endangered species. Significant gaps in understanding and apparent paradoxes in pearly mussel ecology have been exposed. To conserve remaining mussel populations, scientists and managers must simultaneously and aggressively pursue both rigorous research and conservation actions.

Mountain and Highland Ecosystems

16 Bragg, Don C. 2004. **Historical reflections on the Arkansas Cross Timbers.** Journal of Arkansas Academy of Science. 58: 32-36.

Küchler's original map of potential natural vegetation suggested that the eastern-most extension of the "Cross Timbers" oak-dominated woodland reached into extreme western Arkansas. Recent investigations have found possible old-growth Cross Timber communities in narrow strips along steep, rocky sandstone and shale ridges near Fort Chaffee and Hackett. General Land Office surveyors before 1850 reported many ridges and slopes dominated by grassy, stunted oak woodlands, with extensive prairies and richer bottomland terraces. Historical accounts help show that, though far more restricted in this extent than comparable stands in Oklahoma or Texas, Cross Timber communities are possible in Arkansas.

17 Phillips, Jonathan D.; Luckow, Ken; Marion, Daniel A.; Adams, Kristin R. 2005. **Rock fragment distributions and regolith evolution in the Ouachita Mountains, Arkansas, U.S.A.** Earth Surface Processes and Landforms. 30. 429-442.

Rock fragment distribution in the regolith (soil + underlying weathered material) reflects the combined influences of geologic controls, erosion, deposition, bioturbation, and weathering. In Ouachita Mountains regoliths, the rock fragment lithology (shale or sandstone) is not solely determined by underlying bedrock. Fragments move downslope from outcrops, downward by animals, and by gravity into pits associated with rotting tree stumps. Upward movement by treethrow is common. The highest fragment concentrations are in the lower regolith, indicating active production at the weathering front. The action of trees in redistributing rock fragments suggests that Ouachita regoliths have likely been extensively mixed within the last 10,000 years.

18 Phillips, Jonathan D.; Marion, Daniel A.; Luckow, Kenneth; Adams, Kristin R. 2005. **Nonequilibrium regolith thickness in the Ouachita Mountains.** Journal of Geology. 113: 325-340.

Longleaf pine at grass stage *(Zoë Hoyle, USDA Forest Service)*

Interpretations of regolith (soil + underlying weathered material) thickness in the context of landscape evolution typically assume that thickness is controlled by the interaction of weathering rates and erosion, and tuned to topography. However, in the Quachita Mountains, local topography does not explain the high degree of local spatial variability observed. This indicates nonequilibrium—a lack of balance between weathering and removal rates. We apply Johnson's thickness model to interpret local variations in regolith thickness. Results suggest that equilibrium thickness is most likely in uniform lithology with a high degree of lithologic purity, less likely in interbedded sedimentary rocks, and more unlikely still if the latter are tilted and fractured.

Inventory and Monitoring

19 Bechtold, William A.; Patterson, Paul L., eds. 2005. **The enhanced Forest Inventory and Analysis Program—national sampling design and estimation procedures.** Gen. Tech. Rep. SRS-80. Asheville, NC: U. S. Department of Agriculture, Forest Service, Southern Research Station. 85 p.

The Forest Inventory and Analysis (FIA) Program of the U.S. Department of Agriculture Forest Service is in the process of moving from a system of quasi-independent, regional, periodic inventories to an enhanced program featuring greater national consistency, annual measurement of a proportion of plots in each State, new reporting requirements, and integration with the ground sampling component of the Forest Health Monitoring Program. This documentation presents an overview of the conceptual changes, explains the three phases of FIA's sampling design, describes the sampling frame and plot configuration, presents the estimators that form the basis of FIA's National Information Management System (NIMS), and shows how annual data are combined for analysis. It also references a number of Web-based supplementary documents that provide greater detail about some of the more obscure aspects of the sampling and estimation system, as well as examples of calculations for most of the common estimators produced by FIA.

20 Bentley, James W.; Howell, Michael; Johnson, Tony G. 2005. **Louisiana's timber industry—an assessment of timber production, output, and use, 2002.** Res. Bull. SRS-103. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 44 p.

In 2002, industrial roundwood output from Louisiana's forests totaled 720 million cubic feet, 10 percent less than in 1999. Mill byproducts generated from primary manufacturers decreased 4 percent to 275 million cubic feet. Almost all plant residues were used primarily for fuel and fiber products. Saw logs were the leading roundwood product at 273 million cubic feet; pulpwood ranked second at 266 million cubic feet; veneer logs were third at 137 million cubic feet. The number of primary processing plants increased from 57 in 1999 to 60 in 2002. Total receipts decreased 11 percent to 793 million cubic feet.

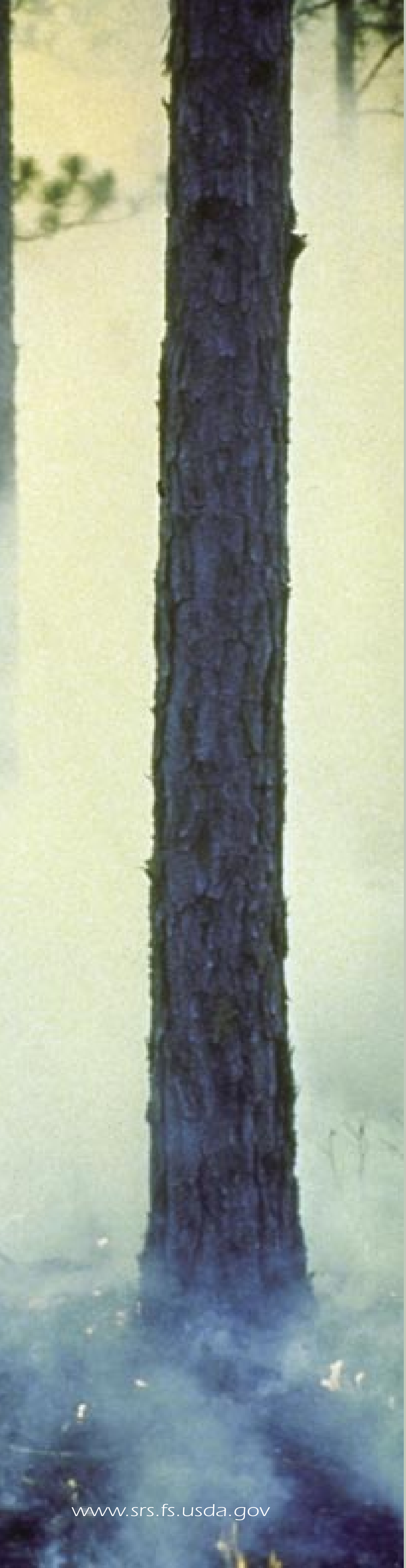
21 Howell, Michael; Johnson, Tony G.; Bentley, James W. 2005. **Mississippi's timber industry—an assessment of timber production, output, and use, 2002.** Res. Bull. SRS-102. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 45 p.

In 2002, industrial roundwood output from Mississippi's forests totaled 927 million cubic feet, 7 percent less than in 1999. Mill byproducts generated from primary manufacturers increased 9 percent to 391 million cubic feet. Almost all plant residues were used primarily for fuel and fiber products. Saw logs were the leading roundwood product at 526 million cubic feet; pulpwood ranked second at 287 million cubic feet; and veneer logs were third at 78 million cubic feet. The number of primary processing plants increased to 116 in 2002. Total receipts increased 4 percent to 888 million cubic feet.

22 Johnson, T.G.; Steppleton, C.D. 2005. **Southern pulpwood production, 2003.** Resour. Bull. SRS-101. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 38 p.

The South's production of pulpwood declined from 63.8 million cords in 2002 to 61.3 million cords in 2003. Roundwood production increased 5 percent to 44.3 million cords and accounted for 72 percent of the total pulpwood production. The use of wood residue dropped 22 percent to 17.0 million cords. Georgia led the South in total production at 9.7 million cords. In 2003, 91 mills were operating and drawing wood from the 13 Southern

Prescribed burning in longleaf pine
(David Teem, Auburn University, www.forestryimages.org)



States. Southern mills' pulping capacity increased from 127,110 tons per day in 2002 to 127,390 tons per day, and still accounts for more than 70 percent of the Nation's pulping capacity.

23 Smith, William D.; Conkling, Barbara L. 2004. **Analyzing forest health data.** Gen. Tech. Rep. SRS-77. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 33 p.

This report focuses on the Forest Health Monitoring Program's development and use of analytical procedures for monitoring changes in forest health and for expressing corresponding statistical confidences. The program's assessments of long-term status, changes, and trends in forest ecosystem health use the Santiago Declaration: "Criteria and Indicators for the Conservation and Sustainable Forest Management of Temperate and Boreal Forests" (Montreal Process) as a reporting framework. Procedures used in five aspects of data analysis are presented. The analytical procedures used are based on mixed estimation procedures.

Large-Scale Assessment and Modeling

24 Achtemeier, Gary L. 2005. **Planned Burn-Piedmont: a local operational numerical meteorological model for tracking smoke on the ground at night: model development and sensitivity tests.** International Journal of Wildland Fire. 14: 85-98.

Smoke from both prescribed fires and wildfires can, under certain meteorological conditions, become entrapped within shallow layers of air near the ground at night and get carried to unexpected destinations as a combination of weather systems push air through interlocking ridge-valley terrain typical of the Piedmont of the Southern United States. With or without fog, smoke transported across roadways can create visibility hazards. Planned Burn (PB)-Piedmont is a fine-scale, time-dependent, smoke-tracking model designed to run on a PC computer as an easy-to-use aid for land managers. PB-Piedmont gives high-resolution in space and time predictions of smoke movement within shallow layers at the ground over terrain typical of that of the Piedmont. PB-Piedmont applies only for weather conditions when smoke entrapment is most likely to occur—at night during clear skies and light winds.

25 Riitters, Kurt H.; Coulston, John W. 2005. **Environmental assessment: hot spots of perforated forest in the Eastern United States.** Environmental Management. 35(4): 483-492.

We identify geographic concentrations (hot spots) of forest located near holes in otherwise intact forest canopies (perforated forest) in the Eastern United States. We describe proximate causes in terms of nonforest land-cover types contained in those hot spots. Hot spots were widely distributed and covered 20.4 percent of the total area of the 10 ecological provinces examined, but 50.1 percent of total hot-spot area was concentrated in only two provinces. In the central part of the study area, more than 90 percent of the forest edge in hot spots was attributed to anthropogenic land-cover types.

26 Sun, G.; McNulty, S.G.; Lu, J. [and others]. 2005. **Regional annual water yield from forest lands and its response to potential deforestation across the Southeastern United States.** Journal of Hydrology. 308: 258-268.

Because of the hot climate and high evapotranspiration in the Southeastern United States, less than half of the annual precipitation that falls on forest lands is available for stream flow in this water-rich region. Water resource management for both floods and droughts demands an accurate estimation of water yield from forests. Projected climate and land use changes further increase the variability of water yield in the region. The objectives of this study were to (1) develop a simple annual water yield modeling procedure, and (2) apply the model to estimate regional forest water yield and predict potential water yield response to forest removal.

Wildland-Urban Interface and Urban Forestry

27 Prestemon, Jeffrey P.; Butry, David T. 2005. **Time to burn: modeling wildland arson as an autoregressive crime function.** American Journal of Agricultural Economics. 87(3): 756-770.

Six Poisson autoregressive models of order p [PAR(p)] of daily wildland arson ignition counts are estimated for five locations in Florida (1994-2001). In addition, a fixed effects time-series

Poisson model of annual arson counts is estimated for all Florida counties (1995-2001). [PAR(p)] model estimates reveal highly significant arson ignition autocorrelation, lasting up to 11 days, in addition to seasonality and links to law enforcement, wildland management, historical fire, and weather. The annual fixed effects model replicates many findings of the daily models, but also detects the influence of wages and poverty on arson, in ways expected from theory. All findings support an economic model of crime.

Foundation Programs

28 Clarke, John W.; White, Marshall S.; Araman, Philip A. 2005. **Effect of stringer repair methods and repair frequency on performance.** Pallet Enterprise. 25(2): 68-73.

Over 135 million wooden pallets were repaired for reuse in 1995. Notched stringers are one of the most commonly damaged components. Metal plates, half companion stringers, and full companion stringers are repair methods described in the United States industry standard published by the American Society of Mechanical Engineers. This study evaluated the effect of these three stringer repair methods on the bending strength and stiffness of 48x40 GMA-style pallets spanning the pallet stringers. Results indicate that all three repair practices (metal plates, half-companions, and full companions), when properly applied, will restore pallet strength when used to repair one notch on one or two stringers of a 48x40 partial 4-way, three stringer pallet.

29 Gan, Jianbang; Onianwa, Okwudili O.; Schelhas, John. [and others]. 2005. **Does race matter in landowners' participation in conservation incentive programs?** Society and Natural Resources. 18:431-445.

This study investigated and compared the participation behavior of white and minority small landowners in Alabama in eight conservation incentive programs. Using nonparametric tests and logit modeling, we found both similarities and differences in participation behavior between these two landowner groups. Both white and minority landowners tended not to participate in conservation incentive programs, and were equally likely to participate in the overall programs—Conservation Reserve Program, Stewardship Incentives Program, and Forestry Incentives Program. The determinants for program participation vary with program and racial/ethnic background. We suggest new approaches to encourage program participation by small landowners in general and by minority landowners in particular.

Longleaf pine savanna
(Zoë Hoyle, USDA Forest Service)

Longleaf pine bark burned from prescribed fire *(Zoë Hoyle, USDA Forest Service)*

Research Work Units

Location & Project Leader	Unit	Name & Web Site	Phone
Asheville, NC David Loftis	4101	Ecology and Management of Southern Appalachian Hardwood Forests www.srs.fs.usda.gov/bentcreek	828-667-5261
Asheville, NC Danny Lee	4853	Eastern Forest Environmental Threat Assessment Center	828-257-4854
Athens, GA John Stanturf	4104	Disturbance and the Management of Southern Pine Ecosystems www.srs.fs.usda.gov/disturbance	706-559-4315
Athens, GA Jim Hanula	4505	Insects and Diseases of Southern Forests www.srs.fs.usda.gov/4505	706-559-4285
Athens, GA Ken Cordell	4901	Assessing Trends, Values, and Rural Community Benefits from Outdoor Recreation and Wilderness in Forest Ecosystems www.srs.fs.usda.gov/trends	706-559-4264
Auburn, AL Kris Connor	4105	Vegetation Management Research and Longleaf Pine Research for Southern Forest Ecosystems www.srs.fs.usda.gov/4105	334-826-8700
Auburn, AL Robert Rummer	4703	Biological/Engineering Systems and Technologies for Ecological Management of Forest Resources www.srs.fs.usda.gov/forestops	334-826-8700
Blacksburg, VA Andrew Dolloff	4202	Coldwater Streams and Trout Habitat in the Southern Appalachians www.trout.forprod.vt.edu	540-231-4016
Blacksburg, VA Philip Araman	4702	Integrated Life Cycle of Wood: Tree Quality, Processing, and Recycling www.srs4702.forprod.vt.edu	540-231-4016
Charleston, SC Carl Trettin	4103	Center for Forested Wetlands Research www.srs.fs.usda.gov/charleston	843-727-4271
Clemson, SC Susan Loeb	4201	Endangered, Threatened, and Sensitive Wildlife and Plant Species in Southern Forests www.srs.fs.usda.gov/4201	864-656-3284
Franklin, NC James Vose	4351	Evaluation of Watershed Ecosystem Responses to Natural, Management, and Other Human Disturbances	828-524-2128
Gainesville, FL Ed Macie	4951	Southern Center for Wildland-Urban Interface Research and Information www.interfacesouth.org	352-376-3213

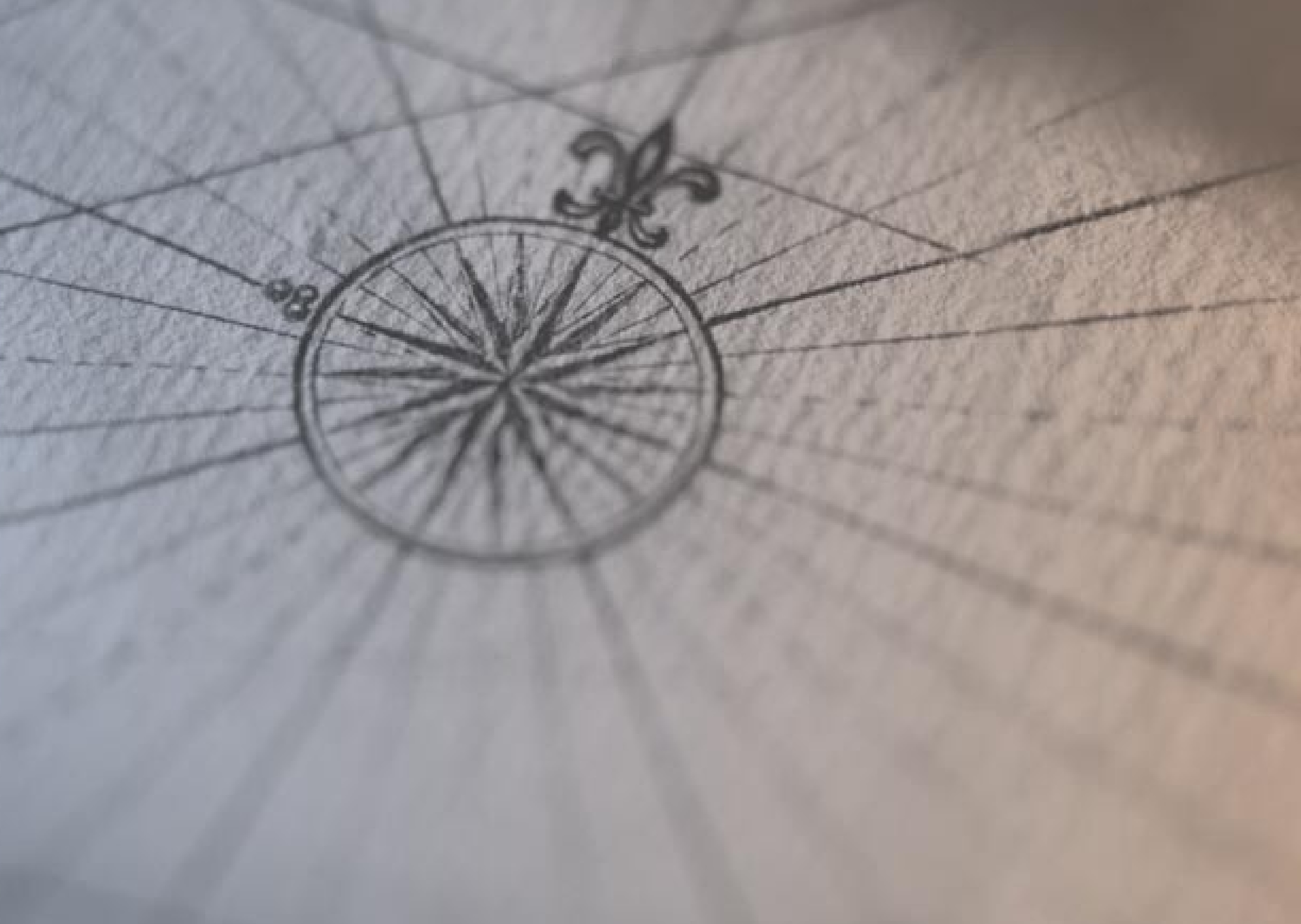
Aerial view of Southern pine beetle damage (Bernd Blossey, Cornell University, www.forestryimages.com)

Research Work Units (Continued)

Location & Project Leader	Unit	Name & Web Site	Phone
Huntsville, AL Greg Ruark	4551	National Agroforestry Center www.nac.gov	256-372-4540
Knoxville, TN Bill Burkman	4801	Forest Inventory and Analysis www.srsfia2.fs.fed.us	865-862-2000
Monticello, AR James Guldin	4106	Managing Upland Forest Ecosystems in the Midsouth www.srs.fs.usda.gov/4106	870-367-3464
Nacogdoches, TX Ronald Thill	4251	Integrated Management of Wildlife Habitat and Timber Resources www.srs.fs.usda.gov/wildlife	936-569-7981
New Orleans, LA Rodney Busby	4802	Evaluation of Legal, Tax, and Economic Influences on Forest Resource Management www.srs.fs.usda.gov/4802	504-589-6652
Pineville, LA James Barnett	4111	Ecology and Management of Even-Aged Southern Pine Forests www.srs.fs.usda.gov/4111	318-473-7215
Pineville, LA Kier Klepzig	4501	Ecology, Biology, and Management of Bark Beetles and Invasive Forest Insects of Southern Conifers www.srs.fs.usda.gov/4501	318-473-7232
Pineville, LA Les Groom	4701	Utilization of Southern Forest Resources www.srs.fs.usda.gov/4701	318-473-7268
Raleigh, NC Steven McNulty	4852	Southern Global Change Program www.sgcp.ncsu.edu	919-513-2974
Research Triangle Park, NC Kurt Johnsen	4154	Biological Foundations of Southern Forest Productivity and Sustainability www.srs.fs.usda.gov/soils/soilhome.htm	919-549-4092
Research Triangle Park, NC William Bechtold	4803	Forest Health Monitoring http://willow.ncfes.umn.edu/fhm/fhm_hp.htm	919-549-4014
Research Triangle Park, NC David Wear	4851	Economics of Forest Protection and Management www.srs.fs.usda.gov/econ	919-549-4093
Saucier, MS Dana Nelson	4153	Southern Institute of Forest Genetics	228-832-2747
Starkville, MS Terry Wagner	4502	Wood Products Insect Research www.srs.fs.usda.gov/termites	662-338-3100
Stoneville, MS Ted Leininger	4155	Center for Bottomland Hardwoods Research www.srs.fs.usda.gov/cbhr	662-686-3154

“Linking science and human purpose, adaptive management serves as a compass for us to use in searching for a sustainable future.”

*—Kai N. Lee, The Compass and Gyroscope—Integrating Science and Politics for the Environment. **



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(Photo by Scott Jackson)

Next Issue...

Thousands of acres of open space are lost to development every day in the United States, with many of these acres converted from private forests owned by individuals, corporations, or the forest industry. The increasing fragmentation of the Nation's forests has a wide range of impacts. Roads cut through forests, interrupting the paths of mammals, fish, reptiles, amphibians, and other creatures. The photo to the left illustrates a "critter crossing" constructed to help animals cross over an interstate highway.

The next issue of Compass *will explore the extent of forest fragmentation in the United States, with a focus on the Southeast.*

Ask A Scientist...

- Do you have a question you would like to ask about fragmentation?
- Email your question to cpayne@srs.fs.usda.gov
- We will feature one of your questions—with answers from our scientists—in our next issue.

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